This MAN-MADE WORLD

by

ANTHONY R. FISHER

This MAN-MADE WORLD

UNIFORM WITH THIS VOLUME

HOW THE WORLD GREW UP
The Story of Anthropology

RACES OF MEN
The Story of Ethnology

HOW THE WORLD SUPPORTS MAN
The Story of Human Geography

MAN AND HIS RECORDS
The Story of Writing

THE TONGUES OF MAN
The Story of Languages

MAN AND HIS CUSTOMS
The Story of Folkways

HOW THE WORLD IS RULED
The Story of Government

MAN AND HIS RICHES
The Story of Economics

HOW THE WORLD LIVES
The Story of Sociology

THOMAS S. ROCKWELL COMPANY
Publishers
CHICAGO

Publishers' Note

This book presents in popular form the present state of science. It has been reviewed by a specialist in this field of knowledge. An excerpt from his review follows:

> *"Mr. Fisher has briefly but clearly shown here the wonderful way in which man has used his two hands and his head to furnish himself with so many useful things and make life easier for himself. Its pages cover the story of thousands of years, from the stone hammer to the steam-engine, from the simple wheel to the railroad train, from the dug-out canoe to the steamship and the airship. The story is simply told, but whoever reads it carefully will learn the exact use of many words that have arisen through these inventions and have become part of our daily speech."*

Signed: Sir William A. Craigie
Professor of the English Language
The University of Chicago

Progress, man's distinctive mark alone,
Not God's, and not the beasts': God is, they are;
Man partly is, and wholly hopes to be.

—Browning

THIS MAN-MADE WORLD

By

ANTHONY R. FISHER

Drawings by

ERNEST RICHARDSON

THOMAS S. ROCKWELL COMPANY
CHICAGO
1931

Printed in the United States of America

CONTENTS

I MAN, THE TOOL-MAKER 11

How has man become master of the world? What was the Neanderthal man like? When did man's mastery begin? How were the first tools made? How was metal discovered? What is the lever? Who invented the bow and arrow?

II HOW POTTERY AND GLASS WERE INVENTED 21

Why was pottery important? What did pottery have to do with art? What was glazing? How was glass discovered? What makes glass?

III HOUSE-BUILDING AND PLOW-MAKING 28

Why is shelter important? What were the first homes? Of what materials were they built? What did food have to do with houses? How did man learn to plant seeds? Who invented the plow? What machinery does the farmer of today use?

IV THE SPINDLE AND THE LOOM 39

Why does man need clothes? What was the first clothing material? How is cloth made? What is a spinster? What is weaving? How did weaving start? What is a loom? What good is sewing? What use is the "eye" of the needle? Who invented the sewing machine?

V FROM BRONZE TO STEEL 50

What is smelting? Why was copper a poor tool material? Why was iron better than bronze? Is steel more important than iron? What were the first smelters like? When was coal used for smelting? What is steel? What is is a blast furnace? What is the Bessemer process?

VI The Wheel and the Sail 60
When did man need inventions for moving? How were things carried? How was the wheel invented? What was the stage coach? How did railroads help? What was happening on the water? How was the first boat made? Why was the sail important? What fault did sails have?

VII Gunpowder and the Printing Press 72
What two inventions brought in the modern era? Who invented gunpowder? Has gunpowder peace-time uses? Who were the first people to use printing? Who invented paper? Who was the first known printer? What did the printing press do?

VIII The Wonders of Steam 81
What good is power? How does steam work? Who made the first steam engine? What was wrong with it? Who invented the first practical steam engine? What was Watt's engine used for?

IX Harnessing the Lightning 91
What is lightning? Who coined the word electricity? What was Franklin's experiment? What is a dynamo? Who built the first telegraph? How does the telephone work? Who discovered "wireless?" Who invented the first incandescent lamp?

X The Automobile and the Airplane 105
Why do autos need a different sort of engine? Who built the first gas engine? When was the first automobile made? When did man first fly in the air? Who invented mechanical flight? When was the first mechanical flight made?

LIST OF ILLUSTRATIONS

"Progress, man's distinctive mark alone——" (frontispiece)
They could kill birds by hitting them with sticks 13
By means of the lever man could move heavy objects 19
Ancient Egyptians made glass by means of blowing 26
In Brazil the natives make huts of palm leaves 31
The first bricks were made of mud mixed with straw 33
It took hours to make a small piece of cloth 46
The bellows was made out of the skin of an animal 55
Carrying goods on oxen was not always satisfactory 61
The first boats were logs hollowed out by burning 67
A blanket perhaps became the first sail by accident 70
The Chinese found a way to make type 77
Humphrey fixed strings to turn the valves 85
It sailed up the Hudson River without the help of sails 90
Franklin sent a kite up into the clouds 95
Field worked to connect America and Europe by cable 99
Edison gave to the world the incandescent lamp 104
The first successful airplane was made by Americans 110

Chapter I

MAN, THE TOOL-MAKER

ANIMALS and man differ greatly in one respect. Man can make tools—tools with which he can control nature. Some animals, it is true, know how to build shelters of different kinds to protect themselves from the weather, as in the case of beavers, birds, and ants; and monkeys sometimes pick up a stick or a stone for a special purpose. But no creature except man knows how to make tools with which to construct things that will add to his comfort and well-being. It is through his inventions that man has become master of the world.

How has man become master of the world?

At the beginning of man's life on the earth, many thousands of years ago, he was almost in the same condition as the animals that lived around him. How do we know this? Nobody who lived in that period wrote about the

kind of life that man lived, because nobody could write. But we can get quite a clear picture of the sort of life that man lived, back in the early Stone Age, from the things that he left behind him.

What was Neanderthal man like?

Ages ago, most of Europe was covered by a great sheet of ice, called a glacier. In the south, however, men of the Neanderthal race were managing to get a living. They were rough, hairy fellows, who walked with a stooping gait. They roamed through the woods and along the gravelly beds of rivers, searching for food, such as wild fruits and berries, grubs, snails, shell-fish, and the like. At night they crept into rock-shelters or caves, where they built fires to keep themselves warm and to frighten away the savage animals.

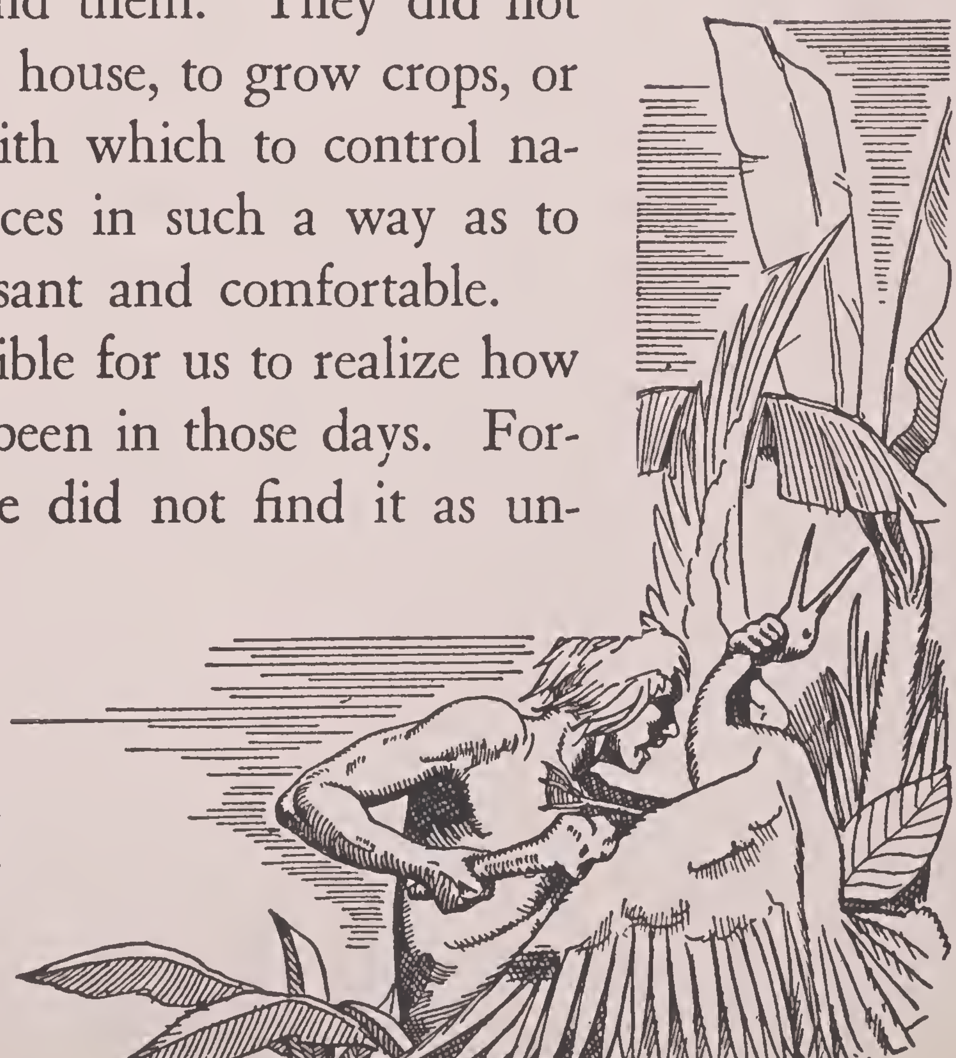
They were almost helpless against these larger animals, for they had no weapons powerful enough to kill them. But they could kill birds and small animals by throwing stones at them or hitting them with sticks. Some-

times they might find the dead body of a larger animal, such as a bison, a deer, or even a mammoth, and then they would feast on the raw flesh, cracking open with stones the large bones in order to get at the marrow.

What tools did they have?

Their only weapons or tools were roughly chipped stones, and probably crude clubs which they made by breaking branches off trees and tearing away the leaves. Some of the stones that we find, which were used by the earliest men, are so rough that it is hard to say whether they were really chipped at all or just happened naturally to be shaped that way. So these men were very little above the wild animals that lived around them. They did not know how to build a house, to grow crops, or to make anything with which to control nature and use her forces in such a way as to make life more pleasant and comfortable.

It is almost impossible for us to realize how hard life must have been in those days. Fortunately, these people did not find it as un-



They could kill birds by hitting them with sticks

pleasant as we should, for they did not know anything better and so it seemed perfectly natural to them.

What was the first step in making the world comfortable?

Man's first step in making life comfortable was his discovery and use of fire. That came very early, for even the men of the Old Stone Age made use of fire. We think that man's attention was first called to fire by the blazes in the forests, set by lightning. No doubt he ran in terror from the hot, scorching, red and yellow flames. Then, when the fire had almost died out, his curiosity made him creep back and gaze at the smoldering heap of embers. If it was a cold night, he may have drawn himself close to the flame in order to get warm. Finally, when the fire showed signs of going out, he may have thrown dry sticks on it and noticed how the fire came to life again. Then perhaps the idea came into his head to take one of the glowing embers to his cave and build a new fire there by piling on to it more fuel.

In that way he kept his fire burning, throw-

ing on dry sticks when it began to die down. It was not until long afterwards that he found out how to "make fire" by striking hard rocks, such as iron pyrites, together and letting the sparks fall on dry tinder. Later still, he discovered other ways of making fire, such as vigorously boring a pointed stick into a piece of wood until a spark came.

When did man's mastery begin?

But with fire alone, man could not have progressed very far, though it kept him warm in winter and was some protection against prowling animals at night. Man's real mastery of the earth began when he learned to make tools, implements, and weapons. As time went on, he learned to make many such things. At first, a tool would be used for many different purposes; later on, special forms of the tool would be made for various kinds of work. First of all, men would pick up stones with sharp edges; they would use the flat side of the stone for hammering, and the sharp edges for cutting and scraping. Then they learned

how to chip one end into a point, while using the flat end for hammering. Then later they began to use the sharp pieces, chipped off the larger stone, for cutting and scraping.

The tool that we use today called a *hammer* tells us something of its early history. The old Scandinavian word *hamarr*, which is the same as ours, meant a rock as well as a hammer.

How were the first tools made?

In the days of the Old Stone Age, the stone tools and weapons that men used were very crude. They were simply stones which the men picked up and roughly fashioned by chipping and flaking. In the New Stone Age, thousands of years later, the stone tools and weapons show very much finer workmanship. They are carefully shaped, and the surface ground and polished. Some of these objects, of a chisel-like form and called *celts,* are very beautiful. They could be used with the pointed ends as picks and with the broad ends as hatchets.

Before long, the makers of these celts realized

that they could be handled much more conveniently if they had handles. So they ground a hole in the stone and inserted a wooden handle, just as the wooden handle of a modern hammer is thrust through a hole in the iron. Or the stone could be fastened to the end of a stick with thongs, or it might be thrust through a hole in the end of a stout stick. Many of these stone hatchets and other things have been discovered buried in the rubbish of the caves where early men lived.

What was the next great step?

But even after the invention of stone tools and weapons, life was no easy matter. It was not until men learned to make things out of metal that they began to take the first steps in civilization. Copper generally was used first, but copper is too soft to make a very useful tool. Then someone discovered that by mixing a little tin with the copper, a much harder metal would be produced. This metal was known as bronze. Later, iron was discovered. Iron was still better for making tools.

How was metal discovered?

The discovery of how to make things out of metal was perhaps an accident. It may be that a party of early men, camping on a rocky hillside, built a big, hot fire on some stones which contained copper ore. In the morning, after the fire had died out, they noticed a number of shiny lumps scattered among the stones, and they found that this substance, while still hot, could easily be hammered into different shapes without breaking.

The trouble with stone tools and weapons was that they were brittle and easily broken. Furthermore, cutting things out of stone was a slow and tiring work. Now here was this new substance, bright and strong but not brittle, which could, with little effort, be made into any shape desired. So copper, and later bronze and iron, began to take the place of stone as the material for tools and weapons.

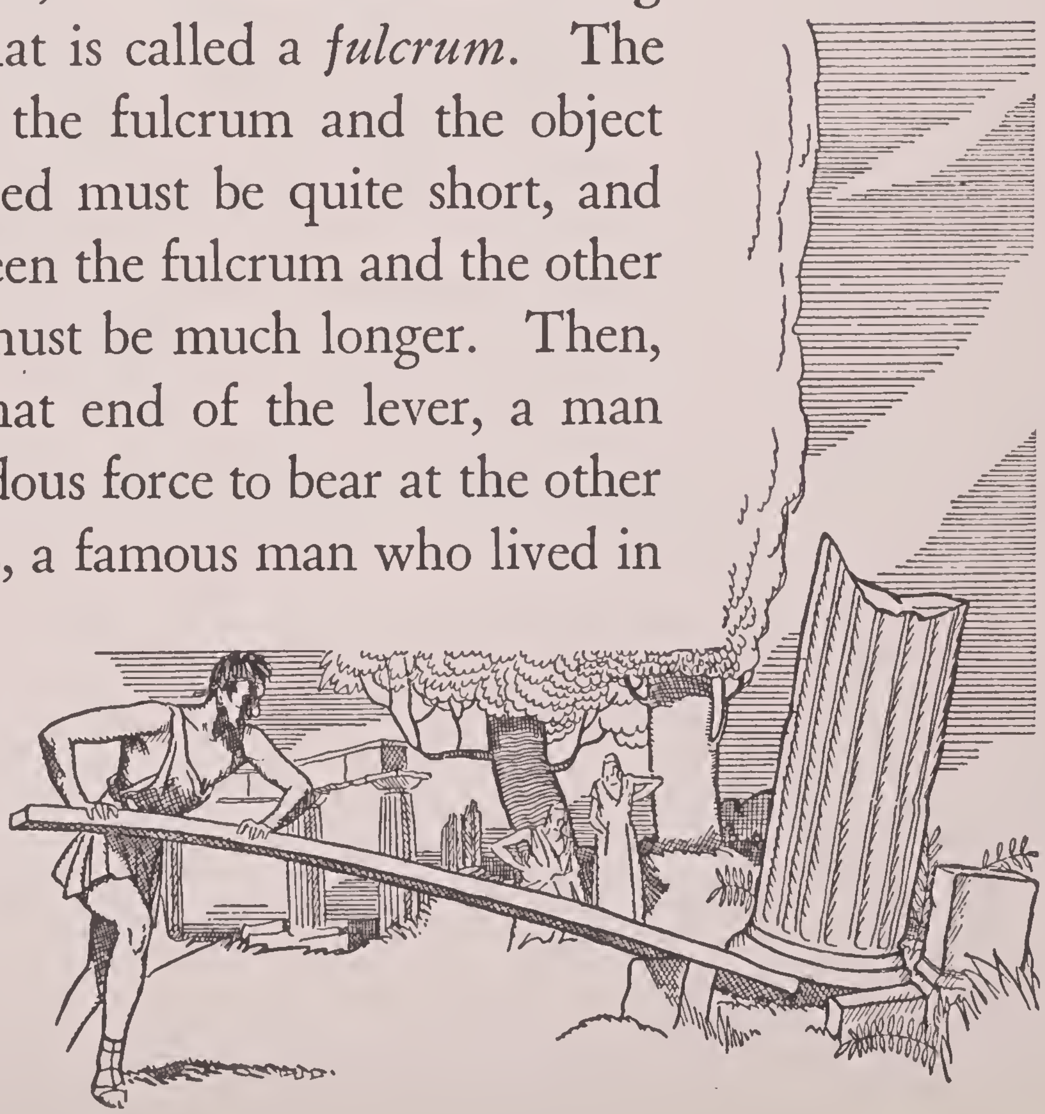
Here again we see how inventions are never altogether new; they always are influenced by the things that already existed. When men

learned the use of metals they did not immediately make strange new tools of different design. No, they used the old patterns that had been used in the making of stone hatchets, hammers, knives, and so on. They simply copied these things in copper, in bronze, and in iron.

What is the lever?

Another very important invention of early man is the *lever*. By means of the lever he could move heavy objects, such as great blocks of stone, that were beyond the strength of his unaided muscles. A familiar form of lever is the crowbar.

To work a lever, there must be something to rest it on. That is called a *fulcrum*. The distance between the fulcrum and the object that is to be moved must be quite short, and the distance between the fulcrum and the other end of the lever must be much longer. Then, by pressing on that end of the lever, a man can bring tremendous force to bear at the other end. Archimedes, a famous man who lived in



By means of the lever man could move heavy objects

ancient Greece, said that with a lever he could move the world—if he only had a place outside to stand on!

Who invented the bow and arrow?

There is one other weapon that man invented back in the early dawn of his life on earth that became useful to him. It has been used by primitive people in so many widely separated parts of the earth that some persons think it was invented not once only, but a number of times, in different countries. This is the bow and arrow. Everybody has seen a bow and arrow; so we all know what it looks like and how it works. The bow and arrow was a favorite weapon of the American Indians. In Europe it was used in the days of the Stone Age and right down through the centuries until the end of the Middle Ages, when the invention of gunpowder made the bow and arrow almost useless in comparison.

Chapter II

HOW POTTERY AND GLASS WERE INVENTED

POTTERY and glass were one of man's first inventions. Every tribe of people finds itself in need of things to keep food, water, and other materials in, where they will be well protected. For instance, the cave where a family lived might be a long distance from the nearest river or spring. The members of the family would frequently feel thirsty. But it was troublesome to have to walk a mile or more whenever one wanted a drink, especially at night or in stormy weather. It was also desirable to have things to keep food in, where it would be safe from prowling animals. Skins made into bags, and baskets fashioned out of straw were of some use; but bags were awkward to handle, and baskets were fragile and would not hold water.

Why was pottery important?

The invention of pottery may have been due to an accident. Probably clay was spread over the outer surface of a fiber basket so that food could be baked or water boiled in it. After the basket had been on the fire for a long time, it would be discovered that the clay had hardened, and when the fiber basket was taken out, there was left a fine earthenware jar or pot.

How was pottery made?

Then men began to make jars and pots by molding clay inside models of fiber or bark and setting them in a hot fire which burned away the covering, the marks of which, on the hardened clay, became a sort of ornamental design. Finally, there came the idea of molding jars, pots, bowls, and jugs directly in wet clay and hardening them by baking.

But this was such slow work. It was a great step forward when someone (we shall never know who) invented the potter's wheel. Paintings on the walls of ancient Egyptian tombs show men making pottery on wheels. The wheel was not what we generally mean by a

wheel. It was a round, flat, wooden table set on a wooden pivot stuck into the ground. The wet clay was placed on the round, flat table, which was made to spin around by a sharp turn with the hand. By keeping the wheel spinning, the potter could mold the clay quickly, and with much less work than before.

The machine was still further improved when a mechanical device was added to it so that the potter could use his foot to make the wheel turn around, thus leaving both of his hands free for molding the clay.

What did pottery have to do with art?

But the Egyptians and other early civilized peoples were not content with plain earthenware jars, pots, and such things. They wanted to make them beautiful, so they made queer designs on them. We have already seen how the first ornaments on earthenware jars came about when the bark or fiber covering was burnt off, leaving marks on the clay. This no doubt first gave the idea to people to make designs on the surface of the clay while it was still soft,

and then when it was baked, the design would be hardened so that it could not rub off.

This was one of the ways in which art began. Those ancient artists learned to engrave and mold on earthenware objects all kinds of beautiful patterns, flower designs, and figures of animals and people.

What was glazing?

But ordinary earthenware is porous; that is to say, it is not absolutely water-tight. Moisture will slowly work its way through, and the jar or similar vessel will become damp, like one of our flower-pots. This trouble was overcome by the invention of glazing. In glazing, a coating of glassy substance is molded on to the surface of the pottery while it is hot. When it cools, this makes a hard, shiny, water-tight outside surface.

The most beautiful pottery of all, of course, is that which we call china. The name tells us where it first came from. It is made from a fine, white, porcelain clay. This clay contains a good deal of the substance (silica) out

of which glass is mainly made. When the clay is put in the fire it is heated so hot that the silica melts and makes not only the surface but the whole material glassy. Chinaware is the most costly and delicate pottery in the world. It was invented by the Chinese many centuries ago, but it is now made in all the civilized countries of the world.

Making glass was another of the great inventions of early man. Here, too, we do not know the inventor's name. Probably the invention was made by different men in different places. Glass is made of silica, with a mixture of other substances. Certain rocks, such as quartz, as well as sand, are rich in silica.

How was glass discovered?

Perhaps glass was first made accidentally when someone built a hot fire on the seashore and after the fire died down noticed that the sand beneath it had melted and formed lumps of a shiny, transparent substance.

Then people began to make glass purposely by melting sand. They were able to make glass

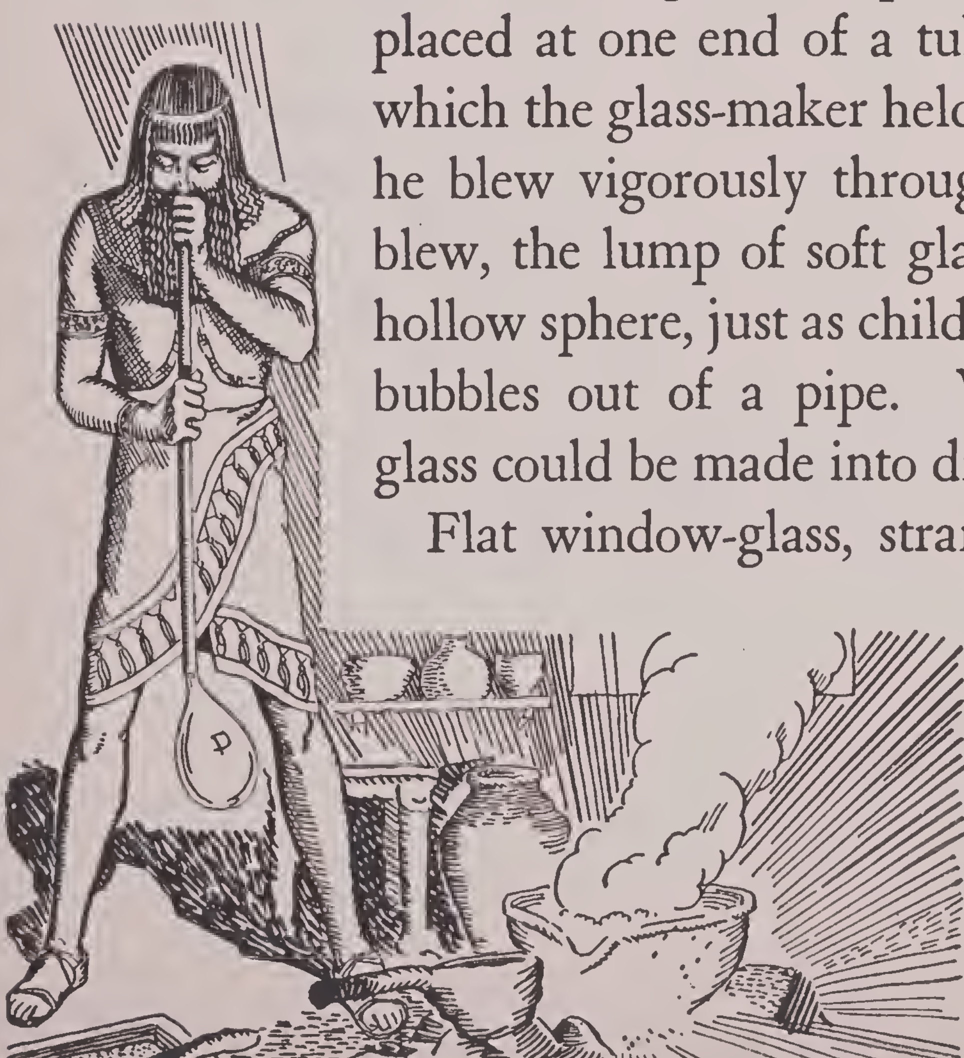
of different colors by adding certain minerals. Ordinary river sand, because of the presence of iron, made a greenish glass, while quartz pebbles made fine, white, transparent glass. The ancient Egyptians were experts in glass-making. Paintings on the walls of Egyptian temples 6,000 years old show men making glass by means of blowing, which they invented.

What makes glass?

The earliest glass objects were made by melting sand in crucibles. While the glass was still soft it was taken out and rolled and drawn into rods, tubes, and flat strips, which were then cut up into the desired shapes.

In blowing, a lump of molten glass was placed at one end of a tube, the other end of which the glass-maker held in his mouth. Then he blew vigorously through the tube. As he blew, the lump of soft glass swelled up into a hollow sphere, just as children today blow soap-bubbles out of a pipe. While still soft, the glass could be made into different shapes.

Flat window-glass, strange as it may seem,



Ancient Egyptians made glass by means of blowing

is also made by blowing a large glass cylinder with a rounded top. Then the top is broken off by heating the air within, the cylinder is cut in two, and the two halves of it while still hot and soft are flattened out.

Why is glass important?

The use of glass as windows in houses became one of the most material aids in man's efforts toward making himself comfortable; especially for those people living in the northern lands. The first houses had no windows. Leaving holes in the walls or leaving the doors open let in rain and snow as well as light. In cold climes this was extremely unsatisfactory. Later, long narrow slits were cut in walls, which let in some light and little rain or snow. Still later, man discovered that greased paper or cloth, membranes of animals, and even horn, when placed across such openings, made a crude window. When glass came into common usage, all this was changed. Homes were no longer damp and dark. Man had taken one more step in making himself comfortable.

Chapter III

HOUSE-BUILDING AND PLOW-MAKING

Why is shelter important?

HIGHER animals and birds are fairly well protected against bad weather. Animals have thick coats of fur to keep them warm, and birds have coverings of soft feathers. But man has very little hair on his body to give him protection against the biting wind and the freezing cold. Life would be terribly uncomfortable if we did not have good houses to live and sleep in, and clothing to wear.

Food, clothing, and shelter are, in fact, the three things that we need most of all. Of course, man has always had to have food, or he could not have lived. But in the earliest days of man's existence he had little clothing or shelter. He roamed around like an animal, searching for food, and, as we have just said, he had little natural protection against the weather. Until

he learned to control the food supply, to build houses, and to make clothing, he could not be happily comfortable.

What were the first homes?

In Stone Age times, people lived in caves (for the possession of which they had to fight with wild animals) and in rock-shelters at the foot of limestone cliffs. Caves had the advantage of being easy to keep warm and of providing good shelter against even the worst storms. But they were dark and gloomy, and there were too few of them.

It was long before the beginning of written history that mankind began its first attempt to build houses. The earliest houses were rude huts. In some parts of the world people still live in such simple huts. In the jungles of Brazil, for instance, the natives take a number of huge palm leaves and arrange them in a circle, with the stalks stuck into the ground and the tops tied together. Other natives of South America bend together some saplings (young trees) and cover the openings with broad leaves.

The American Indians, as we all know, lived in wigwams. A wigwam was made by setting up a circle of tall poles, the tops of which were fastened together and the open spaces covered with skins and sheets of bark. It was easy to build, yet warm inside and a good protection against bad weather. When the tribe moved on to new hunting grounds they took the wigwams with them.

What were the first houses built?

Huts or tents like these were the first houses that mankind anywhere knew how to build. Usually they were so small that a person had to stoop down and crawl into them, and often it was impossible to stand upright in them. One way to make more room was to hollow out the earthen floor of the hut, but a better way was to lift the hut up on posts. That is how real houses were first invented.

But when houses began to be built larger, it was found that the circular form was awkward. It was much more convenient to build them in a square or oblong form. A ridge-

In the jungles of Brazil the natives make simple huts of huge palm leaves

pole was set up to support the slanting poles of the roof. Then it was easy to erect a house with plenty of room for everybody.

Of what materials were they built?

Where timber was plentiful, houses were built of rough logs, and the roofs were often covered with straw. When metal tools hard enough to cut stone were invented, blocks of stone were used for the walls of important houses, such as the kings' palaces and the temples of the gods. Thousands of years ago, in Egypt and Babylonia, brick was invented and used as a building material for houses. This brick consisted of oblong pieces of mud or wet earth mixed with straw and dried in the sun.

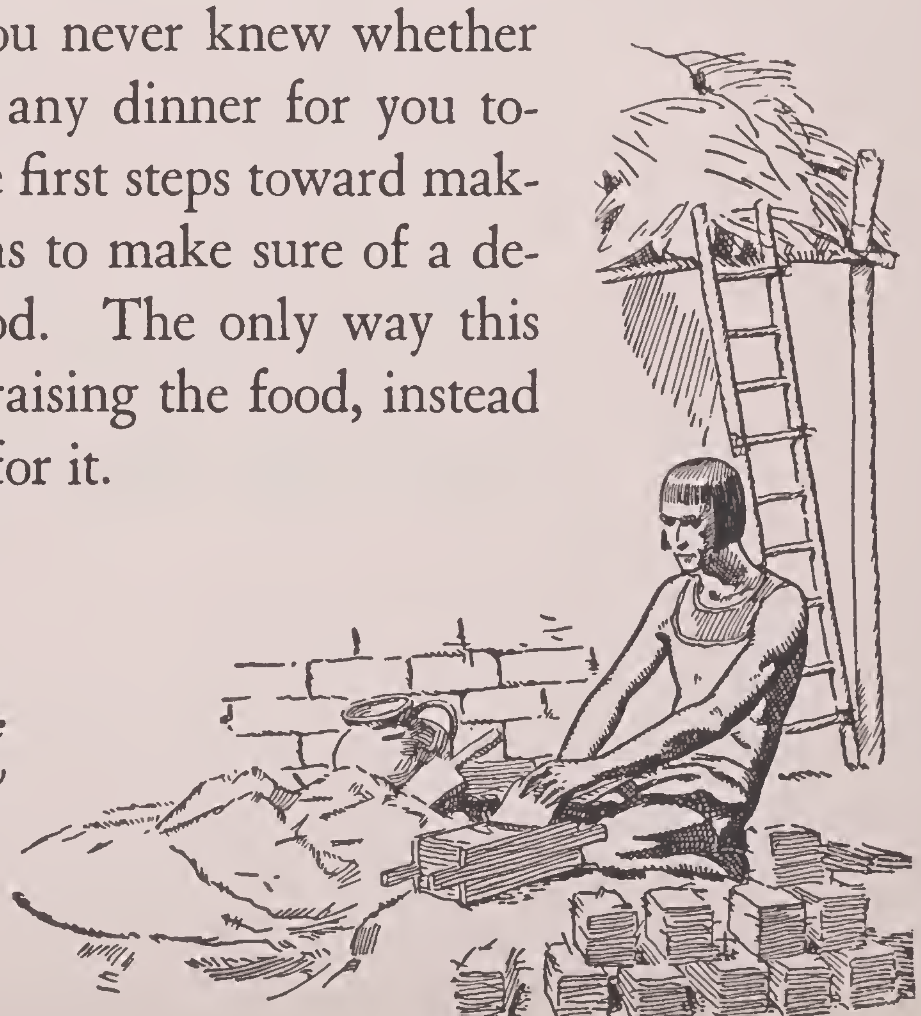
Sun-dried bricks were very good building material in countries where the climate is dry. But of course they did not withstand moisture. In countries where much rain fell, tougher bricks were needed. These were made by baking the bricks in ovens, like pottery. Ovens for baking bricks are called kilns. The Romans made very fine kiln-dried bricks, as well as

earthenware tiles for roofs. They also knew how to make cement.

What did food have to do with houses?

And now, how was man getting along in the matter of his food supply? The men of the Stone Age, as we have seen, roamed around looking for food. Early men everywhere got their food by hunting, fishing, and gathering wild fruits, berries, and such things. The food supply was always uncertain. Sometimes it failed altogether for days at a time, and the people almost starved; while at other times, by a stroke of good fortune, there would be a plentiful supply.

When the food supply was so uncertain, life could not be comfortable. You can imagine how it would feel if you never knew whether or not there would be any dinner for you to-morrow. So one of the first steps toward making life comfortable was to make sure of a dependable supply of food. The only way this could be done was by raising the food, instead of going out searching for it.



The first bricks were made of mud mixed with straw and dried in the sun

How did men learn to plant seeds?

In the beginning, people did not know that plants and trees grew from seeds. They may have learned this interesting fact when grains and vegetable seeds and the hard kernels of wild fruits which they happened to drop while eating their meals, as they squatted on the ground outside of their caves, began to sprout and grow.

At any rate, the time came when they discovered the fact that grains, fruits, and vegetables, if the seeds were planted in good soil, could be grown in large quantities, and that some of them, such as grains, if stored in a dry place, could even be kept through the winter until the next crop was ready to harvest.

The grains that these early men began to raise, such as wheat, rye, barley, and oats, were wild grasses with very small seeds. But after they were cultivated for a long time, the seeds began to get larger and meatier.

The art of raising crops is called agriculture, or farming. Before the coming of agriculture, only a small number of people could live on

even a large piece of land, because the food supply was so small and uncertain. Furthermore, the people had to be moving about from place to place all the time in search of food, and so there could not be towns and cities. But after man learned how to farm, the population increased very rapidly, towns and cities sprang up, and soon great nations were born. All this happened early in history, thousands of years before the time of Christ. Even in those days, countries like ancient Egypt, Babylonia, and China, where farming was practiced, had millions of people living in them.

What invention was needed for farming?

But in order to plant the seeds from which crops are to grow, it is necessary to turn up the soil, and to do that it is necessary to have a suitable tool. We call such a tool a plow. The first plow was probably a pointed stick, such as had been used for digging up roots that could be eaten. Later, a crude hoe came into use, consisting of a long stick with a sharp stone fastened at right angles to the lower end. As

the hoe was dragged along the ground, it made a shallow cut in the soil. The hoe probably was developed from the pick or the hatchet.

Who invented the plow?

The first real plow seems to have been invented, like so many other useful things, by the ancient Egyptians. They have left us pictures of their plows. The Egyptian plow was drawn over the ground by a pair of oxen, guided by a man who walked beside them. Instead of the handle being of one piece of wood, it was made of two pieces, joined together at the bottom, where a sharp iron point was attached. The plowman took hold of a handle in each hand. There was a long wooden pole sticking out in front, and to this pole the oxen were harnessed.

The Egyptians, by means of their plows, made the valley of the Nile one of the greatest food-producing regions in the world. The plentiful supply of food gave many people leisure time in which to cultivate science and art. A part of the population could raise enough food

for all. Thus it was that civilization was born.

By the time of the Romans, great improvements in the plow had been made. A sharp knife, called a coulter, was attached to the front, to make the first cut in the soil. Back of that was a pointed iron "share" for digging the furrow, and a moldboard which turned over the soil and piled it up in a continuous ridge as the plow was pulled over the ground. Another part of the plow, called the landside, pressed against the furrow and kept the plow steady.

What are modern plows like?

In modern times man's inventive powers have invaded the domains of agriculture still further. Today, vast areas of land are worked with "gang" plows pulled by powerful steam or gasoline tractors. With these it is possible for farmers to plow from twenty-five to forty acres a day with ease, where formerly it was back-breaking work to plow five or ten acres in a day. Early in the nineteenth century, McCormick began working on a machine that resulted in the invention of the reaper, or har-

What machinery does the farmer of today use?

vester. From a crude implement which only cut the grain, this harvester has been developed until today it cuts, ties in bundles, and leaves these bundles in rows easy for the farmer to handle. Or else, as in the case of the great wheat fields of the west, these machines cut or "top" the grain and thresh it in one operation. Large trucks moving along beside the harvester catch the grain as it pours from a spout attached to the harvester and when loaded, carry it at once to the marketing centers. For the smaller farms likewise suitable machines have been invented. Small gasoline tractors are used extensively. There are machines for loading hay upon wagons, machines for cutting, shredding, and shelling corn, machines for milking cows on the dairy farms—in fact, all kinds of machines, each of which has tended to make farming easier and more profitable for the modern farmer.

Chapter IV

THE SPINDLE AND THE LOOM

MAN is the only living thing that makes and wears clothing. The animals, as we have seen, do not need any additional protection against the weather. The first clothing that people wore consisted of leaves and bark, or, in colder regions, the skins of wild animals.

Why does man need clothes?

One of the first tools that the men of the Stone Age made was the scraper, a sharp-edged stone tool which was used for scraping the skins of animals killed in the hunt, after the meat had been eaten. In order to make the skins suitable for clothing, it was necessary to scrape off the bits of flesh clinging to the inside. Then, in order to make the skins soft, they were rubbed with fat. Later they were hung over the fire and smoked, thus making them dry and durable, like leather. The Ameri-

can Indians made a beautiful, soft material out of deer-skin, with which they fashioned warm, comfortable clothing, as well as moccasins.

What was the first clothing material?

Animal skins, however, must be "tanned" in order to make real leather. In the manufacture of leather, all the hairs, of course, are first scraped off the hide, which is then soaked in certain chemicals made from the barks of trees. The ancient Egyptians knew how to tan skins, and some very fine leather has been found in their tombs.

Leather is the strongest of all materials for clothing, and leather coats and trousers are still worn by cowboys and other men engaged where the work is hard on clothing. And, of course, leather is still used everywhere for shoes. Furs, also, are much used.

But skins, furs, and leather are too hot for comfort in warm or temperate weather as regular clothing, and they cause an unpleasant feeling when worn next to one's own skin. Woven cloth has been found more suitable.

We do not know when or where weaving was first invented. So many different peoples, all over the world, have been acquainted with the art of weaving that it may have been invented in more than one place.

How is cloth made?

The first step in producing cloth is to make thread. This can be obtained from many kinds of fiber, both animal and vegetable. The fibers are pulled out and twisted together.

Twisting threads entirely by hand, however, is slow and awkward work. The ancient Egyptians, thousands of years ago, invented a machine for spinning thread. Such a machine is called a *spindle.* It is one of man's most important inventions, and, as we are constantly noticing in the case of other inventions, it grew out of something that was already known and in use.

The ancient Egyptian spindle was a tapering reel to which the thread was attached. There was a sort of knob in the middle to make it rotate easily, and a notch at the top in which

the thread was caught while being twisted. The person doing the spinning held, under the left arm or stuck in the belt, a stick or staff upon which a bundle of fibers was bound. This was called the *distaff*. The operator drew out, one after another, the fibers from this bundle and fed them to the spindle, to which a twirling motion was given, as it hung free, by a twist of the operator's hand. Thus the fibers were twisted, and the operator wound them upon the spindle.

How is spinning done?

The next step forward in spinning was the invention of the spinning wheel. Spinning wheels were used in India by early people. They first appeared in Europe during the Middle Ages. The spinning wheel was simply a mechanical means for making the spindle rotate more rapidly and continuously. A large wheel was attached to the spindle by a band. The operator turned the wheel with her left hand, and thus the spindle, which was set in a frame, was made to rotate swiftly.

Another great improvement came into use about the year 1530, when a treadle was added to the spinning wheel. The operator could now use her foot for making the spindle rotate, and thus she had both her hands free for handling the fibers, and she could pull out two fibers at the same time. The distaff containing the fibers was attached to the frame. The rotating of the spindle twisted the thread, which was then wound up on a bobbin.

What is a spinster?

Until about the beginning of the nineteenth century nearly every family kept a spinning wheel. Spinning was the work of girls and women, and as spinning was practically the only work left for a woman to engage in if she did not marry, any unmarried woman came to be called a *spinster*.

In 1767, an Englishman named James Hargreaves invented a machine called the "spinning jenny," in which a number of spindles were turned by a wheel, and many threads were spun at the same time. Other spinning ma-

chines were invented later by Arkwright and by Crompton. The machine of Crompton was improved until it operated 100 spindles. It was called a 'mule,' because it was an offshoot of the spinning 'jenny.' Then, when the steam engine was invented, steam became the power for running these machines. Hundreds of spindles could thus be operated at the same time, and large factories or mills were built to house the machines and the workers. When driven by machinery, the spindles revolved so swiftly that they made over 10,000 turns a minute.

What is weaving?

We must now go back and see how cloth was being woven. Weaving is another of the great inventions of our ancestors thousands of years ago. The ancient Egyptians, the Chinese, and in America, the Aztecs and Peruvians were skillful weavers.

Before people began to weave cloth, they had the idea of weaving. You have all seen matting. Even uncivilized tribes have known how to

make matting. It is made out of strips of grass or straw, plaited together by hand, one set of strips passing over and under the other set, which are laid crosswise to the first set.

How did weaving start?

Now the weaving of cloth was only a short step from the plaiting of matting. There had to be two sets of thread or yarn. One set was called the warp, and the cross-threads, which had to be worked in and out through the threads of the other set, were called the woof.

In the earliest looms the warp threads were stretched out side by side and close together on a frame. Then the weaver worked in the woof threads. This was done either with the fingers or by means of a stick held in the hand. Every other warp thread had to be lifted up separately. This method was slow, and it would take hours to make even a very small piece of cloth.

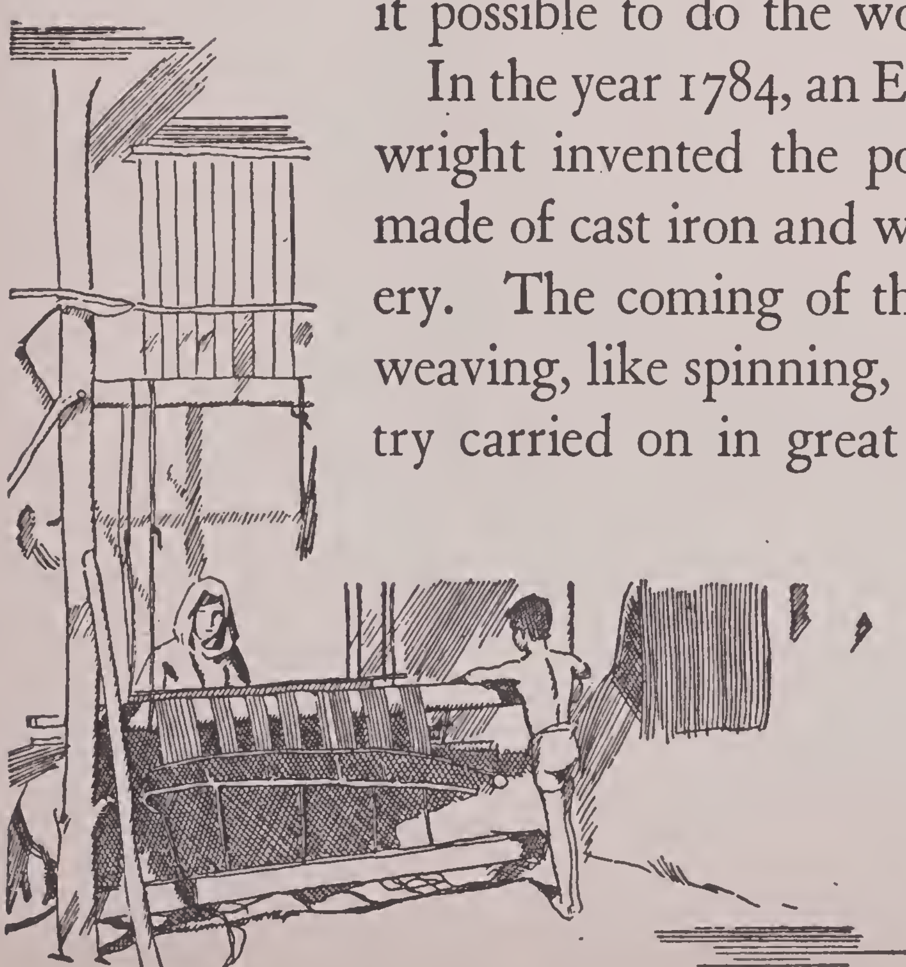
The next invention which saved an enormous amount of time and labor was the use of cross-bars, which in one movement lifted every

other thread of the warp. Then the woof thread could be placed directly across the warp threads. When this was done, the bar was lowered, and the same operation was repeated with the other set of warp threads. Another time-saving invention was the shuttle. This was a heavy weight, to which the woof thread was attached, and it was thrown swiftly across the warp threads when the bar was lifted up.

What is a loom?

This was the kind of loom that was used for hundreds of years, until the beginning of modern times. Then came another improvement. This was the *flying shuttle.* The shuttle was thrown across the warp by levers instead of by the weaver's hand. This made it possible to do the work more rapidly.

In the year 1784, an Englishman named Arkwright invented the power loom, which was made of cast iron and was operated by machinery. The coming of the steam engine turned weaving, like spinning, into a large-scale industry carried on in great factories or mills.



It took hours to make even a small piece of cloth

Closely connected with spinning and weaving there is another and a still older invention which is necessary to the other two, and that is sewing. Cloth would not be of much use if there were not some way of neatly joining together pieces of different shapes and sizes in order to make a garment.

What good is sewing?

The tool with which sewing is done is a needle, to which is attached a piece of thread. Even the most uncivilized tribes usually know how to sew, as did the men of the Stone Age thousands of years ago. The first needles were sharp thorns and narrow pieces of bone, and the first thread was strips of fiber or slender pieces of sinew from the bodies of animals.

The earliest needles did not have holes in the end (called *eyes*) through which the thread passed. The needles were used simply for pushing the thread through holes which had been cut in the pieces of skin that were to be fastened together. But the needle's "eye" was invented many thousands of years ago, for bone

needles with "eyes" have been found among the tools left by the Stone Age men in Europe. Later, when metal-working was invented, needles were fashioned of bronze and eventually of fine steel.

What use is the "eye" of the needle?

When "eyes" were cut in the needle it was no longer necessary to punch a series of holes in the material that was to be sewn, and then push the thread through. The sharp point of the needle was simply run through the skin or cloth, first on one side and then on the other, and as it went through it pulled the thread after it.

Sewing was usually done by women, and a woman who sewed was called a seamstress. Sewing everything by hand was not an easy task and was tiresome work.

As early as 1790, a machine for sewing was invented by an Englishman named Thomas Saint, which had some of the parts that we see in a sewing machine today. In 1830, a Frenchman named Thimonier built a better machine.

It was not until 1846, however, when Elias Howe, an American, patented a new and improved machine, that the real history of the sewing machine begins. In Howe's machine the needle, which was curved, had the eye near the point, and it made a lock-stitch by means of a shuttle on the other side of the cloth, the needle working horizontally.

Who invented the sewing machine?

Other inventors made various improvements, and in 1851, a man named Isaac M. Singer brought out a machine operating with a vertical needle and with power supplied by a foot treadle.

These early machines could do only simple stitching. Since then, machines have been built with special attachments for doing all sorts of sewing, such as embroidery, buttonhole-making, hemming, tucking, and darning. Machines also have been made for sewing leather and carpet. The machine for sewing leather was a great help in shoemaking. Many sewing machines nowadays are run by electricity.

Chapter V

FROM BRONZE TO STEEL

What is smelting?

AS WE have already noticed, man probably first learned the use of metals by accident, from the melting of copper out of rocks on which fires had been built. In some parts of the world, however, copper is found in an almost pure state. The Indians living near Lake Superior used to pick up pieces of this natural copper and hammer it into hatchets, knives, and ornaments. But most copper has to be melted out of rocks before it can be fashioned into things that are useful.

This getting of metal out of rock is called smelting. Copper was an easy metal to smelt. The metal, while soft, could then be hammered into tools and weapons; or while still liquid, it could be poured into molds of stone which had been cut into the right shape. Then, when

the metal had cooled and hardened, the different objects could be lifted out.

Why was copper a poor tool material?

The trouble with copper was that it did not have sufficient hardness and strength to make strong tools and weapons, and the sharp edges dulled quickly. But after a while somebody discovered that by adding about one-ninth part of melted tin to the melted copper and thoroughly mixing them, a very much harder and stronger metal was produced. We call this mixed metal *bronze*. Bronze served the purpose so well that for many hundreds of years nearly all the tools and weapons were made of it. We speak of that time as the Bronze Age.

About the same time, man also discovered iron, but it was not much used then.

There were a number of reasons for this. Iron was harder and stronger than other metals, but in most parts of the world it was difficult to break the ore out of the surrounding rocks. In order to melt the ore a very hot fire was necessary, which required a great deal of fuel

and had to be built in a stone furnace of special construction. Furthermore, most iron was full of impurities; it was hard to get these out, and if they were not taken out, the iron was not of much use.

Why was iron better than bronze?

But iron, when properly smelted, was vastly superior to bronze. It was so much harder and stronger, and could be given a so much sharper edge (especially in the form of steel), that the people who used iron tools and weapons would have a great advantage.

The widespread use of iron seems to have started with the ancient Egyptians. One reason for this may have been the fact that Africa, unlike Europe, was rich in deposits of a fine quality of iron that was easy to get out of the ground. Pieces of iron have been found in the pyramids of Egypt. The Egyptians also learned how to make steel.

Gradually the use of bronze for the more important tools and weapons was given up, and iron took its place. A great step forward

was taken in the history of making the world comfortable when the Bronze Age ended and the Iron Age began. The American Indians never learned the use of iron. Even the Aztecs and the Peruvians were still using copper when Columbus discovered America.

Is steel more important than iron?

Without the special kind of iron which we know as steel, the modern world could not have been born. Our great civilization of today is literally built on a foundation of steel. Steel is a much finer metal than ordinary iron. It is stronger and more elastic; it is not so brittle, and therefore it can stand a much heavier strain. And of course it takes a much sharper edge. Swords made of the famous Damascus steel, hundreds of years ago, were so finely "tempered" that they could sever a delicate hair hanging in the air.

Steel is made by taking the impurities out of iron and adding a little carbon and small quantities of certain other substances. Steel-making was a slow and expensive operation

until modern times. Then science came to the aid of industry and devised quicker and cheaper ways of making steel. Just how this was done, we shall see later.

What were the first smelters like?

As we have seen, for the smelting of iron, the ore had to be heated so hot that an ordinary fire was not sufficient. A special furnace had to be built. The earliest furnaces were made by digging a hole in a hillside and filling it with dry wood, on which the ore was placed. The hole was covered over, except for an opening left in the top through which the hot gases (from impurities in the iron) and the smoke could escape into the air. There was another opening at the bottom, so that a draft would blow through the furnace and make it hotter.

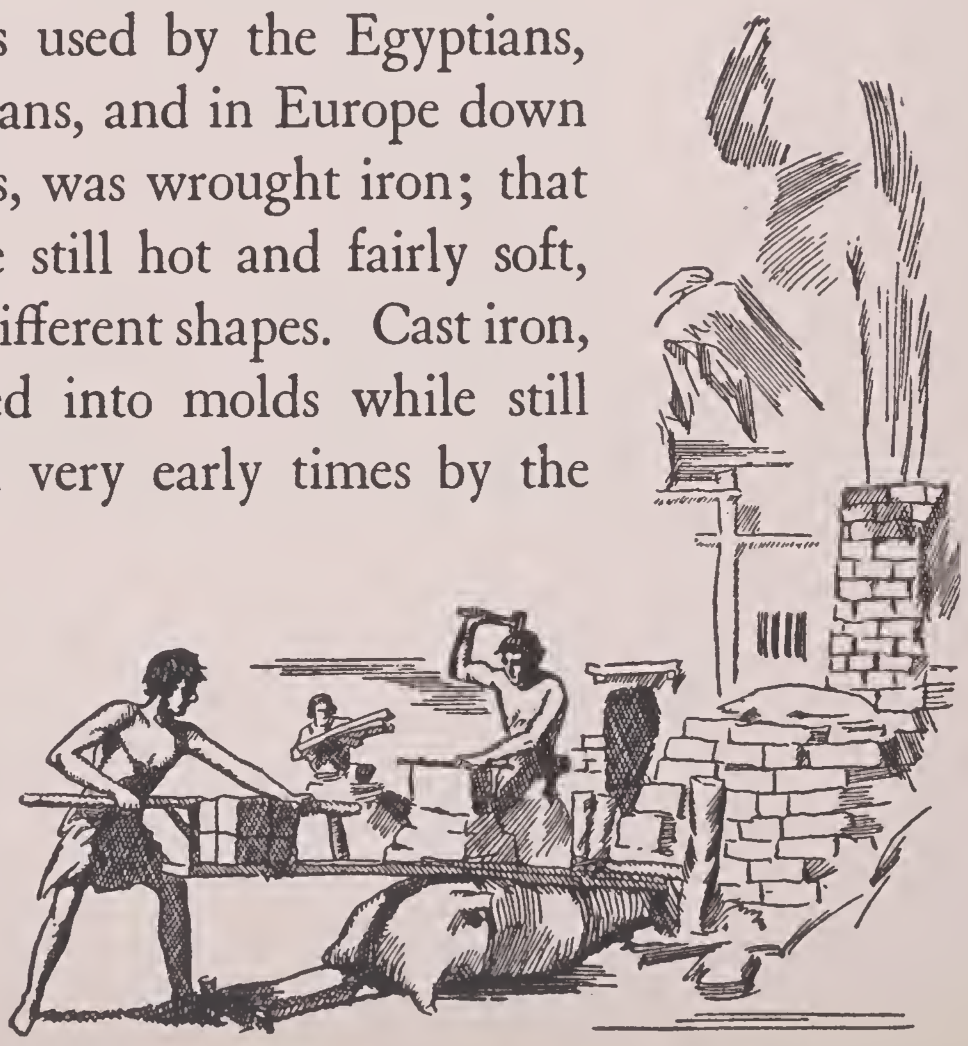
Then some "Thomas A. Edison" of the ancient world invented an artificial furnace for making iron. It was built of stones on the surface of the ground, so that it was no longer necessary to go to some hillside and dig into it. A strong blast of air was blown upon the fire

with a bellows. The bellows was a bag made out of the skin of some animal, such as a goat. It was filled with air and then pressed down, the air being forced violently out through a small hole.

When was coal used for smelting?

Later, instead of wood, charcoal was used in smelting iron. But it took so much wood to make enough charcoal to run an iron furnace that iron smelting could not be done on a large scale until modern times, when coal came into use. Coke, which is obtained from coal, makes an extremely hot fire. Where there were great coal mines near good supplies of iron ore, iron and also steel could be produced in immense quantities at a low cost.

The iron that was used by the Egyptians, the Greeks, the Romans, and in Europe down into the Middle Ages, was wrought iron; that is, iron which, while still hot and fairly soft, was hammered into different shapes. Cast iron, which is iron poured into molds while still liquid, was made in very early times by the



The bellows was a bag made out of the skin of some animal

Chinese, but it did not appear in Europe until the fourteenth century. In order to make cast iron, a very high temperature is required. But cast iron is brittle and is not nearly so useful as steel. We must now look a little more closely into the making of steel.

What is steel?

Steel, as we have already noticed, is a combination of iron and carbon, together with very small quantities of other substances, such as silicon, manganese, sulphur, and phosphorus. The hardness of the steel is determined by the amount of carbon in it. There are also many special kinds of steel, made by combining other substances.

The steel that was made by the people of the ancient world was simply "tempered" iron. The iron while being smelted absorbed a certain amount of carbon from the burning charcoal. Then the iron was made into the desired shape, and, while still red hot, it was plunged into a bath of cold water, which gave it the qualities of steel. This was called "tempering."

It was not until the beginning of modern times that real improvements began to be made in the manufacture of steel. First, the blast furnace was invented. In the blast furnace a quantity of limestone was added to the charcoal and iron ore. Then, when the ore was melted in the strong heat, the impurities in the iron would combine with the limestone and melt, forming what is called a slag. The melted iron, being heavier than the slag, would run down to the bottom of the furnace and the slag would float on top.

What is a blast furnace?

The greatest difficulty in making iron and steel has been to get the impurities out, for iron ore is generally filled with all kinds of base substances that if not removed would make the iron almost worthless. Steel, particularly that used in making railroad rails, which have to stand a great strain, must be free from impurities. So the matter of getting out the impurities has been a serious problem.

In 1740, Robert Huntsman, in England,

produced the first crucible steel. The crude metal was placed in clay crucibles, melted, and refined. Fine steel was made in the crucibles, suitable for tools that required great hardness, a high polish, or sharp edges. Such steel, which is comparatively small in amount, is still made by the crucible method.

What is the Bessemer process?

An important new method of steel-making appeared in about 1850. It was invented in the United States by a man named Kelly, and in England by a man named Bessemer, each working independently. It is generally known as the Bessemer process. It greatly shortened the time necessary for taking out impurities. For this process, huge containers called *converters,* with open tops, are used. They look something like enormous barrels held up by posts at the sides. A stream of air which is forced through the liquid metal carries away the impurities.

About the same time there came into use the Open Hearth process. The ideas from which

it sprang were worked out by Sir William Siemens in England and by two brothers, P. and E. Martin, in France. The crude metal is placed in a furnace, the bed of which is lined with chemicals, and then a gas flame of terrific heat is sprayed over the surface.

What is the Open Hearth process?

Our age has been called the Age of Steel. This is quite true, for modern civilization rests on machinery. Most of this machinery is made of steel, just as are the skeletons of our great skyscraper buildings, our huge bridges, all kinds of tools and implements, and rails for our railroads.

Without the production of great quantities of steel, quickly and cheaply, the kind of world that we live in today, with all its comforts and conveniences, would be impossible. And Mother Nature has been kind to us; she has put into the earth such generous supplies of iron and coal that we need have no fear that they will all be used up in the near future.

Chapter VI

THE WHEEL AND THE SAIL

ONE of the greater problems confronting early man in his effort to make the world more comfortable, was how to travel rapidly from place to place, and also how to move things from one place to another with the least effort.

Why did man need inventions for moving?

In the matter of getting quickly from one place to another, by his own natural power, man was not nearly so well off as many animals. The horse and the deer, for instance, could run faster than he, fishes and even some of the land animals could swim better than he, and the birds could fly—which man could not do at all!

When man succeeded in taming horses, he could climb on their backs and thus travel much more swiftly and for longer distances than he could when he depended on his own legs to

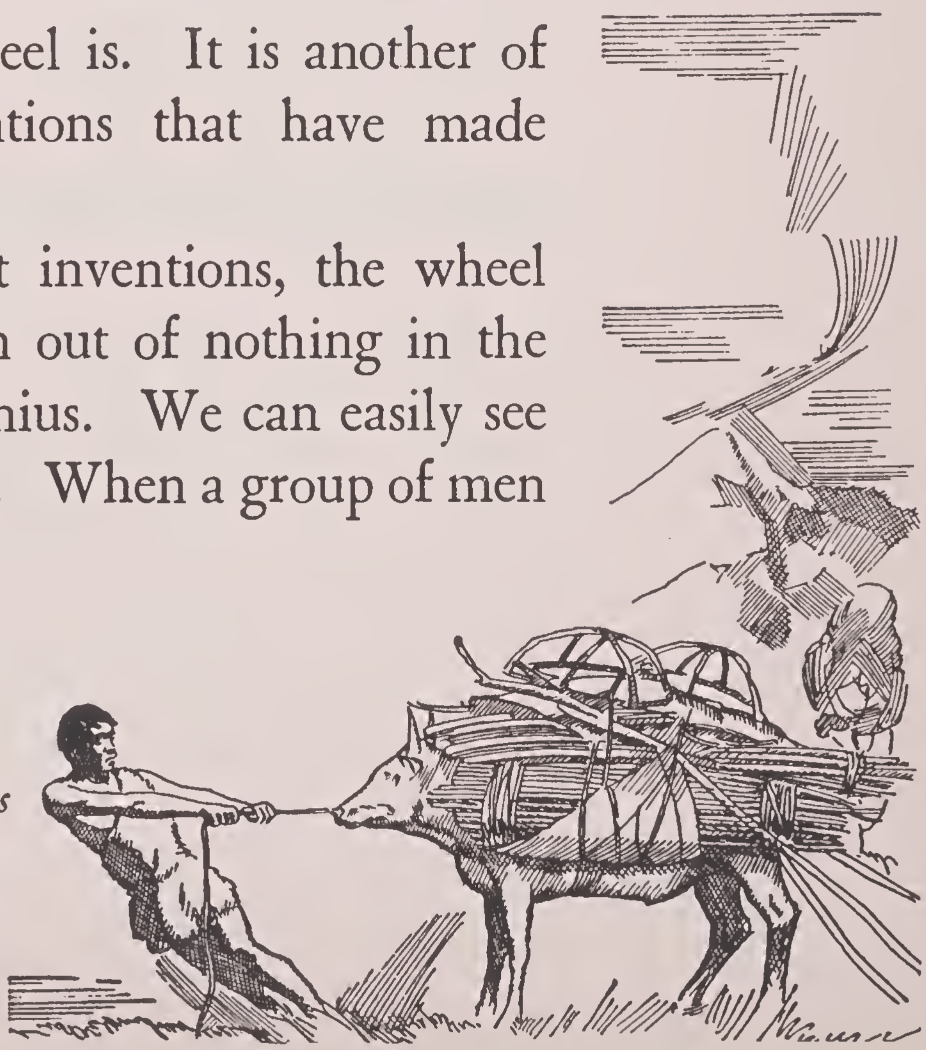
carry him. But riding on horseback, especially for a long distance, was uncomfortable and sometimes impossible.

How were things carried?

For carrying goods, also, one could use animals such as horses, donkeys, oxen, and camels. But this was not always satisfactory, for the goods had to be strapped to the animal's back and were liable to fall off and get damaged. Of course the goods might be piled on rough sledges and dragged over the ground, but the sledges were apt to get stuck.

The first step in solving the problem of transportation on land came with the invention of the wheel. We are all so familiar with wheels of many kinds that we do not realize what a wonderful thing a wheel is. It is another of the great basic inventions that have made civilization possible.

As with other great inventions, the wheel was not suddenly born out of nothing in the head of some great genius. We can easily see how it evolved or grew. When a group of men



Carrying goods on oxen was not always satisfactory

were trying to move a heavy object, such as a block of stone, over the ground, the idea probably occurred to one of them, perhaps after the block of stone had got stuck, to chop down some young trees, tear off the leaves and branches, and lay the trunks on the ground under the stone. Then it was easy to push the stone along. The poles simply rolled over and over, and when one of the poles was left behind by the moving stone it could be carried to the front again.

How was the wheel invented?

Then another idea popped into the head of some man. He took a large tree trunk, cut off the branches and scraped away the bark, so as to make the outside very smooth, and chopped it into a length of about five feet. He cut away the middle part, leaving only a narrow connection between the two large, circular ends. These ends served as crude wheels. Between these wheel-like ends he could then place a great wooden box, fastening it so the primitive axle could rotate beneath the bottom of the

box. He then had a rude cart. This cart could be very easily pulled over the ground.

How was the wheel improved?

Another improvement was made when the wheels were cut separately, each with a hole in the middle. Then two wheels were fastened together, one to each end of a pole or axle, which remained fixed in position and the wheels revolved around it. Still later, the manner of building a wheel was further changed. A strong, circular rim of wood was constructed and connected by means of stout spokes to a hub in the middle; that is, a small wooden object shaped like a keg, with a hole for the axle to go through. To the outside of the rim was fastened a metal tire to save wear.

Until the invention of railroads, about one hundred years ago, the wheeled carriage was the best means that the world had for carrying people and goods on land.

Carriages were first built so long ago that we do not know when they first appeared. Even so ancient a people as the early Egyptians knew

how to make beautiful chariots, some of which have been found, well preserved, in the tombs of their kings. The Romans, too, made handsome chariots, drawn by swift horses. The Romans were fond of holding chariot races.

There have been various forms of wheeled carriages. Before the coming of the railroads, people used to travel long distances in stagecoaches. Stagecoaches were a familiar sight in the western part of the United States until comparatively recent times.

What was a stagecoach?

A stagecoach was a large, high carriage, capable of carrying quite a number of people, together with their baggage, and also the mails. It was drawn by four or even six horses. It was called a stagecoach because it was drawn by different sets of horses, each set pulling it a certain distance, or *stage*. One set of horses would pull the coach for a number of miles until it reached the next town or city, where a new set of horses would be waiting. Then the tired horses would be unhitched and fresh ones

harnessed in, and these would pull the coach at a fast speed to the next stopping place, where another relay of horses would be waiting, and so on. In that way, the coach could travel swiftly for hundreds of miles.

How did railroads help?

Of course when the railroads came, both the engines (locomotives) and the cars needed wheels. The wheels of railroad cars have to be very strong to bear up the immense weight of the cars; and it was found to be better to have the axles turn with the wheels instead of being fixed. Railroad trains made traveling on land much speedier and more comfortable than it had ever been before. Instead of moving over the bare ground, the wheels were placed on smooth steel rails, so that the train sped along without jolting.

A different kind of car was built for carrying merchandise, and these cars were hauled in long trains called freight trains. These trains could carry immense loads of all kinds of material as far as necessary. Before the invention of

railroads, transportation on land was so expensive that only light and costly goods could be shipped any great distance.

The building of railroads was made possible, of course, by the invention of the steam engine, of which we shall have more to say in another chapter. It was not until long after the railroads had been serving mankind that the automobile and the airplane were invented. These two wonderful inventions have still further increased man's ability to move from place to place quickly and comfortably.

What was happening on the water?

In the meantime, how was man solving the problem of moving himself and his belongings over the water?

The first boat was undoubtedly a floating log. By sitting astride the log and pushing against the water with his legs and arms, or paddling with a stick, a man could cross a river or a lake, or reach some island off the coast.

But solid logs were heavy and hard to manage. It was difficult to stay on them, and

The first boats were logs hollowed out by burning and hacking

How was the first boat made?

still more difficult to carry any baggage on them. So somebody hit upon the idea of making the log hollow. This was done by burning and hacking out with a hatchet a large hole extending nearly the entire length of the log. Then it was found that by chopping the ends of the log into points it would move through the water more easily.

Tribes in many parts of the world have been very skillful in building these "dugout" canoes. They could move very swiftly through the water by means of paddles plied by the men sitting in them. Columbus, on one of his voyages, saw in the waters of the West Indies "dugout" canoes large enough to contain seventy or eighty persons.

But it was not always easy to find good tree trunks of just the right quality and size. Furthermore, hollcwing them out was slow and painful work. As time went on, it was found that a much better boat could be built by fashioning a keel and a number of "ribs" of

wood and then nailing boards upon them. The new boat was widest in the middle and tapered at both ends. It was steered by means of a rudder at the stern, and it was pushed through the water by oars.

These boats were far better than the old "dugouts." But when a boat was heavily loaded or had to make a long journey, rowing was not equal to the job, because it was very hard work and the rowers quickly got tired. Transportation on water would never have progressed very far had it not been for the sail.

The idea of the sail probably was born when a man in a little boat stood up and held part of his blanket out against the breeze. The wind, striking the broad surface of the blanket, pushed the boat along through the water without any effort on the part of the man. If it was a sharp breeze, the boat was pushed by the wind much more swiftly than the man could row or paddle.

How was the sail invented?

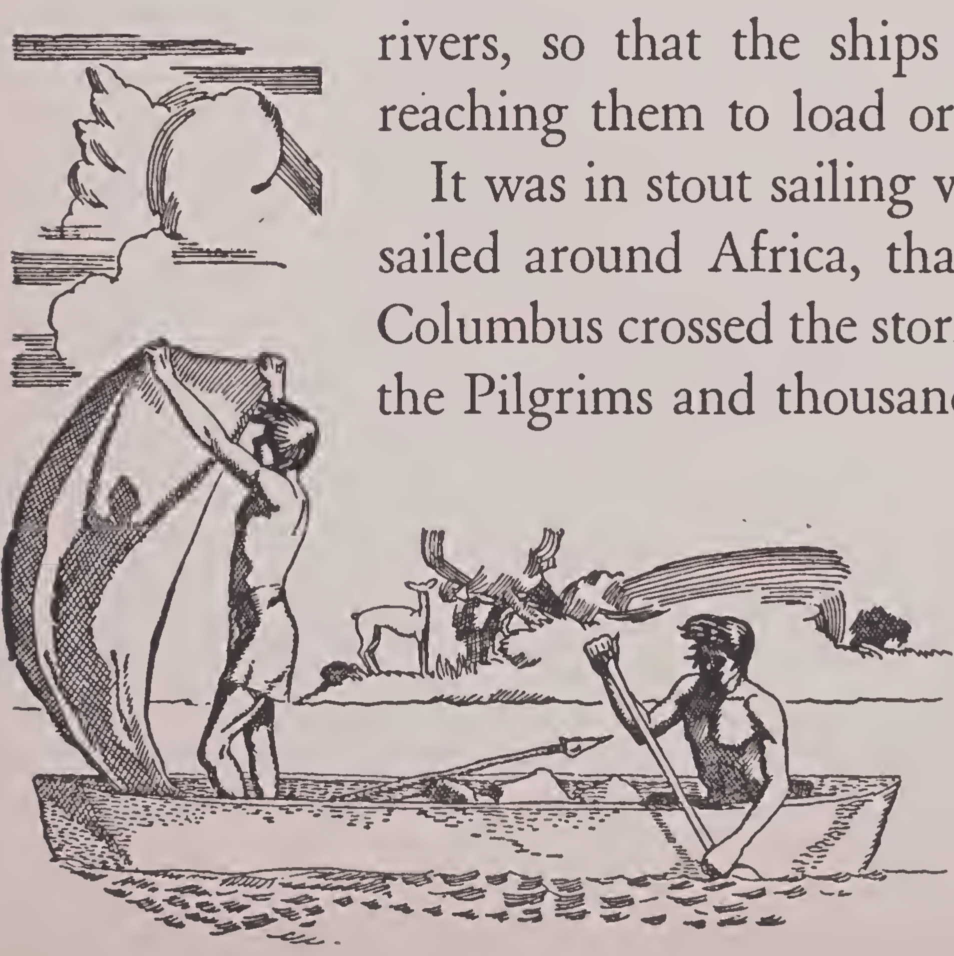
From this, it was an easy step to stick a tall pole into the middle of the boat and fasten to

the pole a cross-piece of wood to which was attached a large sheet of cloth, the ends of which were tied to the bottom of the mast or to some other part of the boat.

Why was the sail important?

With the help of one or more sails, boats of very large size, covered over with decks and filled with heavy cargoes of merchandise, could travel over the water for long distances without any physical labor of human beings, except for the work of managing the sails and steering. Power that comes from the winds costs nothing, and so water transportation was very much cheaper than transportation on land, especially since a boat could carry more people and goods than even the largest carriages or wagons. Cities and towns were built close to harbors or deep rivers, so that the ships had no difficulty in reaching them to load or discharge cargoes.

It was in stout sailing vessels that brave men sailed around Africa, that the Norsemen and Columbus crossed the stormy Atlantic, and that the Pilgrims and thousands of other early pio-



A blanket perhaps became the first sail by accident

neers came from Europe to America in order to make their homes here.

The chief trouble of sailboats, of course, was that the winds were not always dependable. Sometimes they blew the wrong way, and sometimes they died down altogether and left the ship becalmed.

What fault did sails have?

After the invention of the steam engine, steam began to be substituted for sails on large ships. First, paddle-wheels were built on the sides of the ships. But they were very awkward, and soon were replaced by propellers built into the end of the ship next to the rudder and under the water line. The engines of many ships today are run by oil, so that the ship does not have to carry immense loads of sooty coal to feed the powerful engines.

A swift steamship now crosses the Atlantic in less than five days—a voyage that took Columbus two months.

Chapter VII

GUNPOWDER AND THE PRINTING PRESS

DURING the time called the Middle Ages people were still living in much the same way that they had lived for thousands of years. There were few of the comforts that everybody enjoys today, and for most people, life was very hard. Then there appeared in Europe two great inventions which had such a wonderful effect upon the world that the Middle Ages ended and a new era began—the modern era in which we are now living.

What two inventions brought in the Modern Era?

These two inventions were very different things: one was gunpowder, and the other was the printing press. Strange as it may seem, both gunpowder and printing were first invented in China hundreds of years earlier. But they effected little change in the way that people lived in China. There were a number of reasons

for this: one was that the Chinese had a religion which taught that the people should always live in the way their ancestors did.

Who invented gunpowder?

Now let us see about gunpowder. It is composed of saltpeter (potassium nitrate), sulphur, and charcoal. The Chinese, as we have just been saying, had been making gunpowder for hundreds of years, but they used it only for fireworks. They loved to set off firecrackers and enjoyed the loud noise they made. But in Europe gunpowder was used for a very different purpose. As we all know, when a spark is applied to gunpowder, it explodes with terrific force. In Europe this force was harnessed for shooting balls of iron out of cannon and balls of lead out of guns.

In the Middle Ages the common people in many countries had few rights. They were almost slaves. The good things of life, such as there were then, were enjoyed by a few fortunate people called nobles. The rest of the people lived in terrible poverty and ignorance.

The nobles lived in castles with thick stone walls and ditches around them filled with water. These great nobles were constantly fighting among themselves; and sometimes, led by their king, they fought against the king and nobles of some neighboring country. The soldiers were mostly men called knights, in the service of the nobles. The knights (on horseback) wore suits of shining armor made of iron and steel, which were a good protection against the weapons of those days, such as pikes, spears, battleaxes, and arrows. In great wars, of course, many of the common people had to fight, and they were at the mercy of the nobles in their great castles and the knights in armor.

How did gunpowder change things?

Gunpowder changed all this. For cannon, shooting heavy iron balls, could batter down the thickest castle walls; and the common man when he went to war, armed with a gun, could shoot right through the armor of the proud knights. This made the ordinary people a great deal more important than they had been before.

Furthermore, the people who lived in cities did not need any longer to build great high walls of stone around them, within which they were cooped up. Stone walls were no protection against cannon; for defending themselves they now depended upon more and better guns than their enemies had. So the ugly walls around cities were torn down, and the cities could spread out and grow, giving everybody more room and becoming more healthful places in which to live.

Has gunpowder peace-time uses?

Gunpowder has been useful in peace, as well. With explosives men could blast rock in quarries for building purposes, farmers could blow up stumps of trees that interfered with plowing, and engineers could cut tunnels for railroads through the midst of great mountains.

Meanwhile, the other great invention, the printing press, was doing its part to bring the modern world into life.

As we have seen, the Chinese had long been familiar with the art of printing, but had made

little out of it. The idea out of which printing sprang is so simple that we wonder why people like the Egyptians, the Greeks, and the Romans did not invent printing presses. These peoples had signet rings, and they knew that by smearing some black substance on a signet ring they could make an impression of the pattern or design. The Greeks, and the Romans, too, knew how to stamp pictures and words on coins. But they never invented printing. Why this was so, we shall see a little later.

Who were the first people to use printing?

The Chinese method of printing, for hundreds of years, was to engrave on a large wooden block a whole page of writing, then spread ink over it, and press it down on a sheet of paper. After the necessary number of pages had been printed, they could be put together into a book; and, of course, there could be as many copies of the book as there were copies of each page printed. When a whole page was engraved on one block, the type was of no use afterwards for printing other books. In about the eleventh

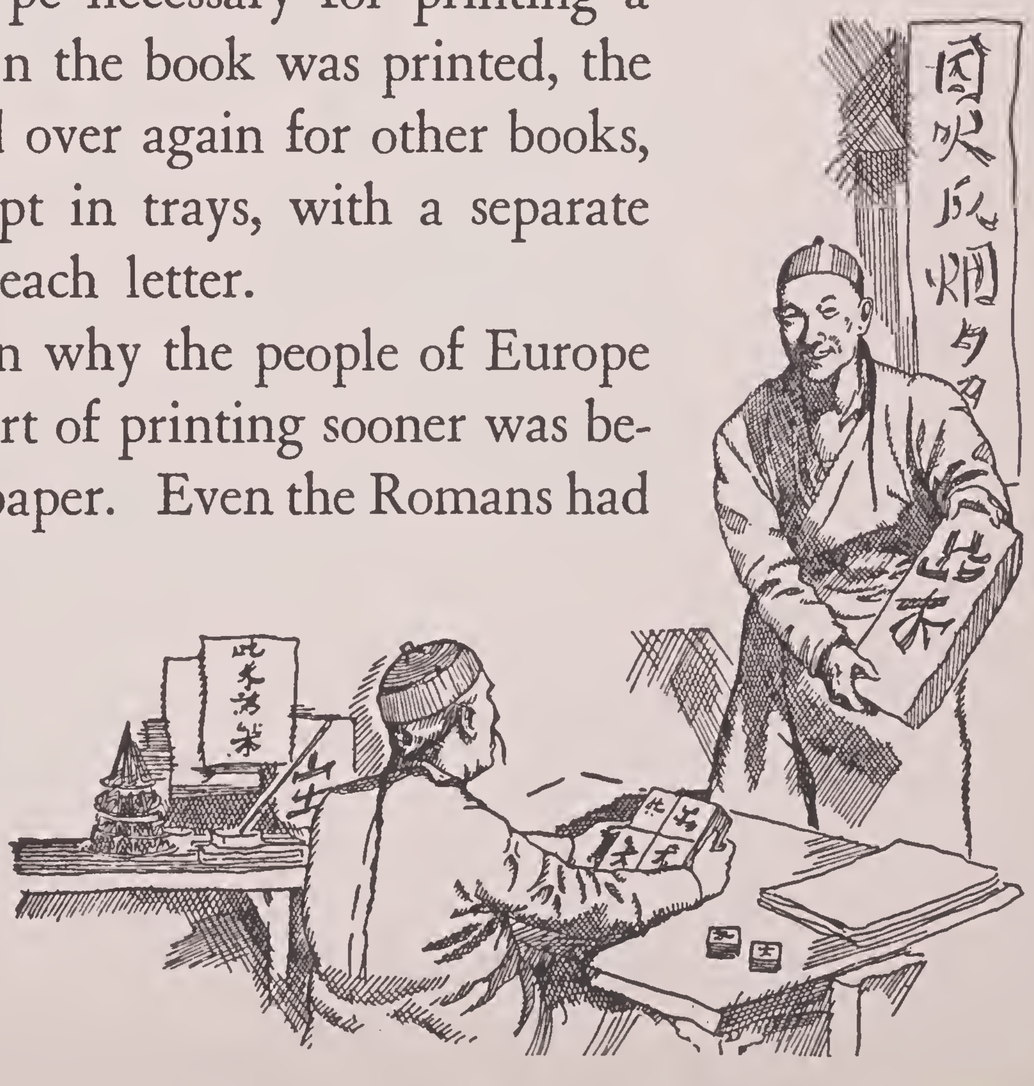
century, however, the Chinese began making separate types. They were molded out of a kind of earthenware called *terra cotta.*

Why did not the Chinese develop printing?

But Chinese printing was slow and expensive, because the Chinese have no alphabet. Every word is written with a separate picture-sign, of which there are about 40,000 in use. You can see how terribly troublesome it must be for a printer to have to search through 40,000 pieces of type to find the right one for each word.

The different countries of Europe, on the other hand, all had alphabets of about two dozen letters, each letter representing a sound. Using a simple alphabet, it would be quite easy to pick out the type necessary for printing a book. Then, when the book was printed, the type could be used over again for other books, the type being kept in trays, with a separate compartment for each letter.

One great reason why the people of Europe did not learn the art of printing sooner was because they had no paper. Even the Romans had



The Chinese found a way to make type

to do most of their writing with a sharp-pointed instrument called a stylus on waxed tablets. Important writing was done on polished skins called parchment and vellum, which were extremely expensive.

Who invented paper?

The Chinese, again, knew how to make paper. Paper is made from vegetable fibers ground into a pulp and then flattened out under great pressure. The art of paper-making had to come to Europe before printing would be worth while. And that is what actually happened. It was the Mohammedans who brought paper into Europe, by way of Persia and Arabia. After they conquered Spain, they began making paper in that country. Before the year 1400, there were paper mills in France, England, and Germany.

Printing began in Europe in a very small way. First, the scribes who made the costly hand-written books called manuscripts began to print the large, artistic initial letters from engraved wooden blocks. Some people think

that between 1420 and 1446 a man named Laurens Coster, who lived in the town of Haarlem, in Holland, began to make type and to print books. But we cannot find any copies of his books, if he did print any; so we are not sure that he was the first printer.

Who was the first known printer?

But we do know that about the year 1438, in the city of Strasbourg, on the Rhine, a man by the name of John Gutenberg built a small printing press. It was merely a little wooden stand on which the type was set up, inked, and pressed down on sheets of paper.

About 1450, Gutenberg moved to another city not far away, called Mainz, or Mayence. Gutenberg was poor, but he entered into a partnership with a wealthy man named Faust, who furnished the money to enable Gutenberg to begin printing books. Gutenberg then began to make books. They were very beautiful ones, and many of them are still in existence. One of the first books printed by Gutenberg was the Holy Bible. Copies of the Gutenberg Bible

are now worth thousands of dollars. One of them was recently purchased by the United States government for the Library of Congress.

In a short time after Gutenberg began printing books, other printing presses sprang up all over Europe. A man named William Caxton established the first printing press in England, near London, in 1474.

What did the printing press do?

The printing press did more to spread knowledge among the people than did any other invention. With that knowledge, men began to learn more of Nature's secrets so as to make life more worth-while than it had ever been before. And the spread of knowledge helped to prepare the people for self-government.

Of course, great improvements have been made in the printing press since Gutenberg's time. Nowadays printing presses are immense machines of iron and steel, run by electricity. Even the type-setting is no longer done by hand, but by wonderful machines such as the linotype and monotype.

Chapter VIII

THE WONDERS OF STEAM

GUNPOWDER and the printing press alone did not make the sort of world that we live in today. It was the invention of the steam engine that first gave man the power to harness a great force of Nature and put it to work for him. Before the day of the steam engine practically all the work of the world was done by the muscles of men and of animals such as horses and oxen. This invention gave to man great iron muscles—muscles that never grew tired—for doing all kinds of work.

What good is power?

The steam engine was a slave, but a cheerful, willing slave. All it asked was food and drink —a certain amount of coal and water daily.

Steam is simply water heated until it becomes a gas. When water in a pot or kettle is heated over a fire, the water slowly begins to change

to steam, which rises to the surface in little bubbles and escapes into the air. We say that the water is boiling. When the steam strikes the air, it is cooled again and condensed into vapor; that is, little particles of water floating in the air and looking like a small white cloud.

How does steam work?

Now, steam is different from water, in that it is what we call expansive. In other words, it spreads out with great force. If a kettle of boiling water is covered and no place left for the steam to escape, the lid will be blown violently off. This is the force that makes the steam engine work.

The power of steam had been known for many hundreds of years before any real use began to be made of it. An ancient Greek named Hero, who lived in Alexandria, a great city of Egypt, more than one hundred years before the time of Christ, made a sort of steam engine, but it was little more than a plaything.

Hero's engine was a metal globe set on a covered basin with which it was connected by

tubes on each side. At the top and at the bottom of the globe there was a short bent tube, open at the end. The basin was filled with water and a fire lighted under it. When the water began to boil, the steam rushed up into the globe and burst out into the air through the open tubes with great force, making the globe revolve, something like a lawn sprinkler.

Who made the first steam engine?

In the seventeenth century, when the great discoveries of Galileo awoke a widespread interest in science, a number of men tackled the problem of making a steam engine that would do useful work. An Italian named Porta constructed a curious little engine that would pump water from a tank by forcing steam into the tank. A little later another Italian named Branca made a machine that would turn a wheel by blowing a jet of steam on blades around the rim.

At the end of this century, an Englishman, Thomas Savery, brought forth an engine which developed power by means of steam and

air pressure from the outside operating on a vacuum (a place from which the air has been mostly removed). The vacuum was created by sending steam into a receptacle and then condensing it into water. Savery's engine was able to pump water up from a mine or a well. But it was not used much, because it required an enormous amount of fuel.

Who invented the piston?

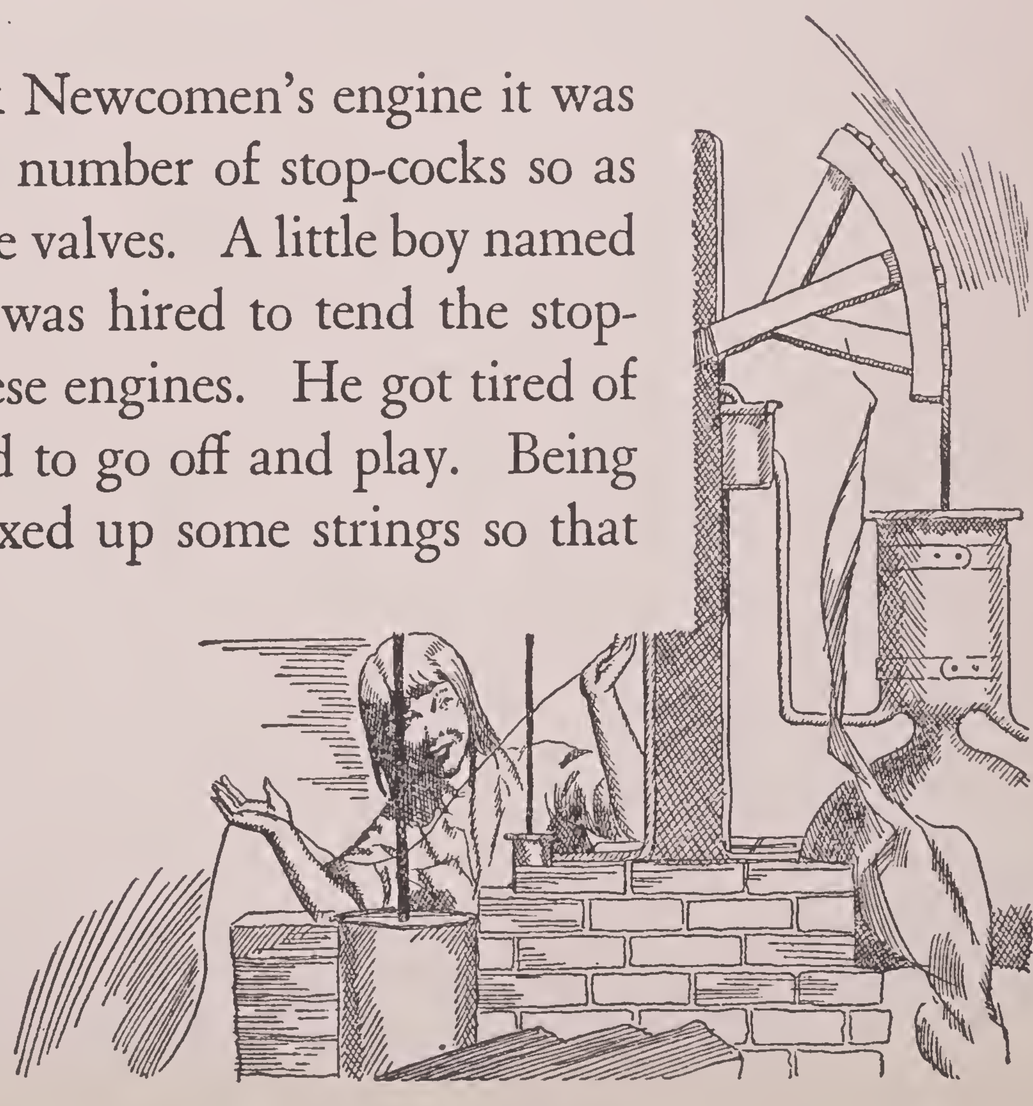
Early in the eighteenth century, another Englishman, named Newcomen, working with Savery and a third man, built a steam engine which made use of a piston, a device that had been invented by a French scientist named Papin and used by him in a little engine. Papin's engine, because it was very awkwardly constructed, was not a success. Newcomen's engine was not much of a success, either, but the piston was the key which, in the hands of another man, was destined to unlock the power of steam.

We shall see now how this happened. Newcomen's engine was a peculiar one. A piston

is simply a little disk of metal on a rod, the disc fitting snugly into the inside of a hollow metal cylinder. In Newcomen's engine the cylinder was filled with steam and then cold water was let into the cylinder, which made the steam condense and form a vacuum. Then a heavy pressure would be exerted on the piston by the pressure of the air on the outside, so that the piston would be pushed down very vigorously. Then it would be pulled up by means of a weight, and the operation repeated over again, as first steam and then water were let into the cylinder. So it was really the air pressure and not steam directly that moved the piston.

How did Newcomen's engine work?

In order to work Newcomen's engine it was necessary to turn a number of stop-cocks so as to open and shut the valves. A little boy named Humphrey Potter was hired to tend the stop-cocks on one of these engines. He got tired of the job and wanted to go off and play. Being a bright boy, he fixed up some strings so that



Humphrey fixed strings to turn the valves

the engine would turn the stop-cocks itself. That was a valuable improvement.

When the piston on Newcomen's engine moved down, it set in motion a large beam which was attached to a pump-rod. The engine could make twelve strokes of the piston in a minute, each stroke being capable of lifting fifty gallons of water a distance of fifty yards. The Newcomen engine was more useful than Savery's, and engines of this type were used rather extensively for pumping water out of English mines, especially the coal mines.

What was wrong with it?

But even the Newcomen engine was very expensive and wasteful. It used twenty-eight pounds of coal each hour for every horse power (a horse power is the unit of measurement of the work done by steam engines), whereas later types of steam engines used only two pounds of coal hourly per horse power. A large Newcomen engine burned up $15,000 worth of coal in a year. The result was that it did not pay to use the engines beyond a certain point. A

better engine was needed badly, and when a real need for anything exists, somebody generally comes along and supplies it.

Who invented the first practical steam engine?

That is what happened. A young Scotchman named James Watt made the improvements which have earned for him the title, "Father of the Steam Engine." For the steam engine that was destined to give birth to a new era in industry was born in the ingenious mind of James Watt.

He was employed as a mechanic by the University of Glasgow, his job being the making and repairing of mechanical instruments used in the university's laboratories.

In 1763 (thirteen years before the Declaration of Independence was signed in America), a small Newcomen engine, the property of the university, got out of order. It had been sent to London for repairs, but the mechanics there had been unable to put it in working order. So it was turned over to young Watt.

Watt was a very thoughtful and painstaking

young man. He did not just tinker with the Newcomen engine. No, he first sat down and made a thorough study of the whole subject of steam and mechanics. Then he began to examine the engine very carefully and to make himself thoroughly familiar with it.

He saw that there was a great waste of time and energy in forcing cold water into the cylinder in order to condense the steam and then depend upon the pressure of outside air to force the piston down. Why not, he asked himself, use steam instead of air to work the piston?

There were many other problems that he had to solve. For nineteen years he worked over his steam engine. At last he was satisfied, and in 1782 he patented his engine.

How did Watt's engine work?

In the steam engine, as finally perfected by Watt, steam was forced first against one side and then against the other side of the piston, pushing it back and forth continuously. Furthermore, Watt, like a good Scotchman, got every ounce of work that he could out of his

steam. He put in a valve so that the supply of steam going into the cylinder was cut off when the piston had made only about one-quarter of the stroke, for he knew that the steam, after it got into the cylinder, would go on expanding sufficiently to drive the piston all the way. Thus he more than doubled the amount of work that steam would do.

In short, James Watt, although indebted to other men for some of the ideas on which he built, is the real creator of the steam engine.

What was Watt's engine used for?

Watt's steam engine had unlimited possibilities. It was not just a contrivance for pumping water out of coal mines. People soon realized that it could be made to do all kinds of other work. Before long it was harnessed up to spinning and weaving machines, and great mills and factories began springing up all over Great Britain.

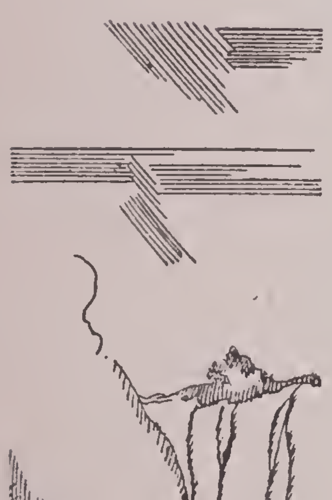
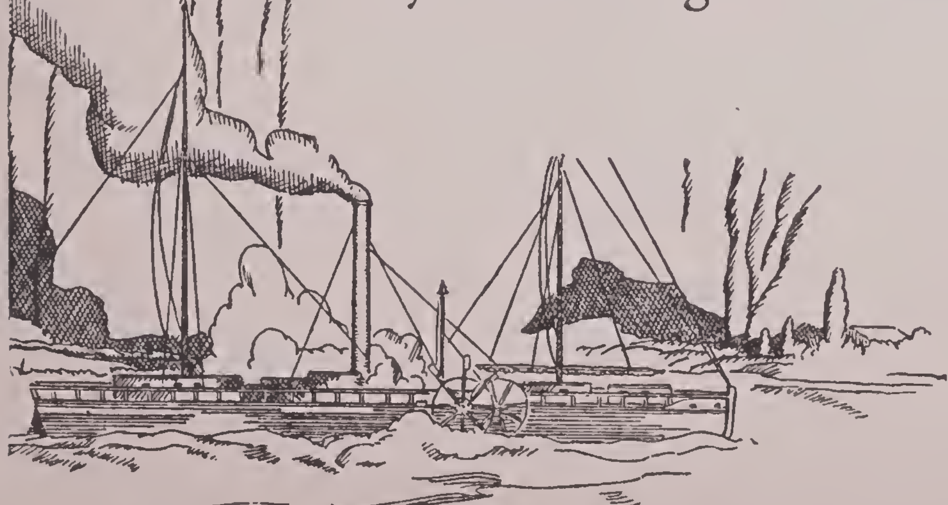
Early in the nineteenth century an American named Robert Fulton fitted a steam engine into a little boat, which sailed up the Hudson River

without the help of sails or oars. A little later an Englishman named George Stephenson built the first steam locomotive for pulling carriages on rails, and soon in many countries railroads were bringing towns and cities much nearer to each other.

Who built the first steam locomotive?

Of course, as time went on, further improvements were made in the steam engine. A way was found for making the steam do still more work by forcing it into other cylinders after it pushed the piston in the first one. These were called "double expansion" and "triple expansion" engines. They made a great saving in the amount of coal that had to be used.

A more recent form of steam engine, and a very powerful one, is the turbine, which operates by throwing jets of steam against bladed wheels. This is the idea that the Italian, Branca, experimented with over 300 years ago. The modern turbine engine came into use in 1884. Many of our great ocean liners are driven by turbine engines.

It sailed up the Hudson River without the help of sails or oars

Chapter IX

HARNESSING THE LIGHTNING

PEOPLE are often frightened by the terrific power that runs wild in a bolt of lightning. When it hits a building it does fearful damage, and once in a great while it kills someone without a moment's warning. Yet the same power, when produced by man and properly harnessed and directed, is the most useful servant that man has today. It does many more things for him than steam can do. Not only does it run engines; it lights his home, it carries his voice across continents and oceans, and it even brings him wonderful music from far away. We call this great power *electricity*.

What is lightning?

We know just what steam is; we know that it is simply water heated until it becomes a gas. Nobody knows what electricity is; it cannot be seen or handled or weighed. But man has

learned to control it and to put it to work for him in many different ways.

The ancient Greeks, 2500 years ago, noticed the strange fact that a piece of amber, or of certain other substances, when rubbed briskly caused tiny bits of light material, such as cloth, if held near, to jump to it and cling there. But nobody had any idea that the mysterious power that made the bit of cloth jump to the amber was the same as that which threw the mighty lightning bolts across the sky.

Who coined the word electricity?

It was not until the seventeenth century, about 300 years ago, that men tried to learn more about electricity by actual experiment. An Englishman, Sir Thomas Browne, coined the word *electricity;* we first find it in a book that he published in 1646.

In the eighteenth century real progress began to be made. It was found that some objects will give off electricity, while others will not, also that electricity can be passed from one object to another.

About 1745, a strange kind of bottle called the Leyden jar aroused a great deal of interest among people in Europe and in America. A man named Cunaeus, while visiting a friend's laboratory in the city of Leyden, in Holland, happened to pick up a bottle of water in which an electrically charged wire was dipping, and with his other hand touched the wire. He got a violent "shock." Later, it was found that the same effect could be brought about by using an empty bottle coated with tinfoil on both the outside and the inside and then charged with electricity.

What was a Leyden jar?

The Leyden jar attracted the attention of Benjamin Franklin, one of the greatest Americans that ever lived. He studied the problem and showed just how the "shock" was caused. By connecting a number of Leyden jars one to another he was able to produce a "shock" of such great force that it nearly killed him.

Now a number of men began to think that perhaps the force that nearly knocked them

down when they took hold of a Leyden jar might be the same as lightning.

Franklin decided to find out by experiment whether this was true or not by trying to bring down some of the lightning from the sky and bottle it up in a Leyden jar. It was a dangerous experiment, for lightning is not something that can be played with safely.

What was Franklin's experiment?

At last the day for the great experiment arrived. During a thunderstorm Franklin and his young son, standing under a shed, sent a large kite up into the clouds. To the end of the long cord holding the kite he had attached a metal key. Franklin held the cord by a silk ribbon, silk being what is called a non-conductor; that is, electricity does not pass through it. As the lightning flashed up in the sky, Franklin noticed that the fibers of the cord began to bristle, like a cat's fur. He cautiously touched his knuckles to the key. Presto! a spark jumped from the key into his hand. Filled with excitement, he brought together the key and the

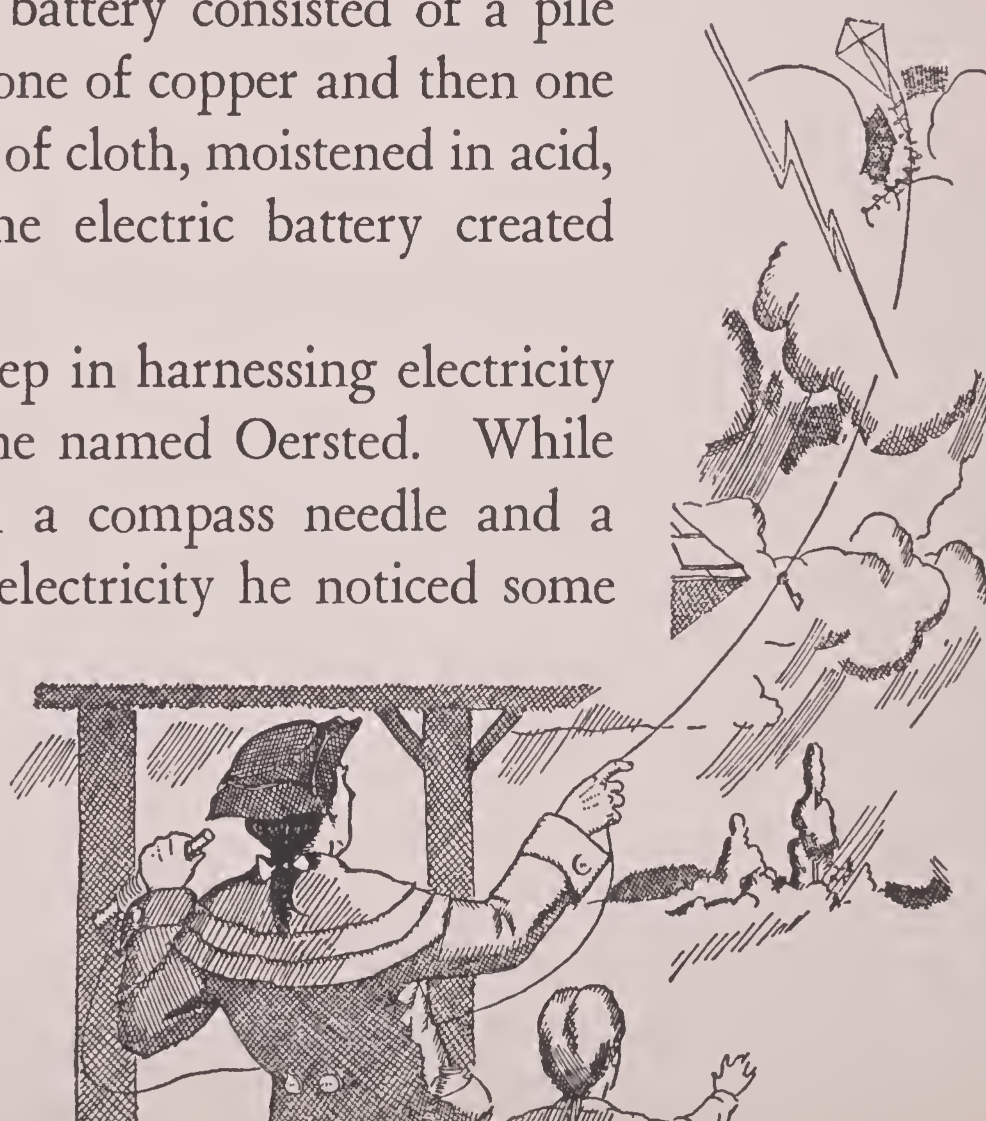
Leyden jar. The Leyden jar was immediately electrified and acted in the same way as when it was charged with electricity produced by rubbing. What a beautiful experiment it was!

A direct result of Franklin's experiment was the invention of the lightning rod, which farmers put up on the roofs of their houses and barns. These tall rods act as protection against lightning bolts.

Who invented the first battery?

We may say that electricity, as a great servant of mankind, really was born in 1800, when an Italian named Volta invented the first electric storage battery, producing a continuous current of electricity. The battery consisted of a pile of metal discs, first one of copper and then one of zinc, with a piece of cloth, moistened in acid, between them. The electric battery created great excitement.

The next great step in harnessing electricity was made by a Dane named Oersted. While experimenting with a compass needle and a wire charged with electricity he noticed some



Franklin sent a large kite up into the clouds

unusual effects. The needle behaved very strangely. He saw that there was a close relationship between magnetism and electricity. In 1820 he announced to the world his great discovery.

This discovery led to the invention of the electromagnet. This was one of the most amazing inventions ever made by man. The electromagnet consisted of an iron magnet with a wire wound around it. By winding the wire in a certain way, the magnet was made to spin around as long as the current lasted.

Who invented the electromagnet?

It was on Christmas day, in the year 1821, that a young Englishman named Michael Faraday put into operation his electromagnet. Faraday was the son of a blacksmith and had started out in life as a London newsboy. He educated himself and became an assistant in the laboratory of the great scientist, Sir Humphrey Davy. The story of his life and work reads like a wonderful fairytale.

Thus was electricity harnessed so that it

was made to do actual work. Electric motors of greater and greater power were developed for running all sorts of engines, operating street-cars, and the like. An electric motor is much the same as an electric dynamo. A dynamo is a machine for producing electric current, while the motor is a machine that receives a current and produces mechanical power. The wire coils are wound somewhat differently.

What is a dynamo?

We now come to another wonderful invention. A wire was wound around a small iron bar, and whenever an electric current was sent through the wire the bar became magnetized. By turning the current on and then off, the bar would attract and then release another little piece of iron placed near it, making a clicking sound as it did so. In this way it was possible to send signals over a wire for long distances. A man sitting at one end of the wire would work a little key up and down, turning the current on and then off, and the instrument at the other end of the line would respond.

It was an American, Samuel F. B. Morse, who built the first telegraph line. It was three miles long. By combining short and long clicks, called dots and dashes, he was able to make a different signal for each letter of the alphabet. His experiment was so successful that Congress gave him the sum of $30,000 with which to construct a telegraph line from Baltimore, Maryland, to Washington, D. C., and in 1844 the first telegram was sent over the wire from one city to another.

Who built the first telegraph?

Then people began to wonder if a telegraph line could not be laid under the ocean to connect America and Europe. That was a daring idea. Think of it, a wire 3,000 miles long, resting on the bottom of the ocean! Furthermore, the wire would have to be placed in a thick rubber covering to keep the electricity from escaping into the water.

A man named Cyrus W. Field worked for many years at great expense in an attempt to lay such a cable between the two continents.

Cyrus W. Field worked for years trying to lay a cable between America and Europe

In the year 1858, he succeeded in making the connection, but the cable broke. Then the Civil War came along and operations had to be stopped. But after the war, Mr. Field went ahead again, and in 1866 the United States and England began talking with each other across the ocean.

Who invented the telephone?

If messages could be sent at lightning speed over telegraph wires, might it not be possible to send the human voice itself over the wires? That was the most daring idea that had occurred to any inventor up to that time. Probably no inventor ever faced more discouragement and ridicule than did Alexander Graham Bell, the inventor of the telephone. People thought he was crazy; even after success was in his grasp he was laughed at as "a crank who says he can talk through a wire."

Mr. Bell was not even a scientist. He was a teacher in a school for deaf and dumb children! But this work had led him to make a careful study of the human ear to find out

how it carried sounds to the brain, for it is in the brain that we hear sounds. What he discovered made him feel sure that the telephone was a possibility.

How does the telephone work?

He set to work to make an artificial eardrum out of a thin disc of metal. By talking upon this disc, he made it vibrate a piece of iron connected with an electromagnet. Then he connected, with a long piece of wire, this electromagnet with another to which was attached a similar disc. One was the transmitter, and the other the receiver. When he talked into the transmitter, the vibrations of the disc made changes in the electric current, and as the current reached the other end it made the disc at that end vibrate in the same way as the first disc. And when these vibrations struck the eardrum of the person holding the receiver, he heard sounds—the sounds made by the person talking at the other end of the wire.

This sounds very simple as we tell about it now. But it was only after long and patient

experimenting that success crowned Bell's efforts. At the great exposition held in Philadelphia to celebrate the one hundredth anniversary of the Declaration of Independence, Bell gave a public demonstration of the telephone. Today there are millions in use throughout this and other countries.

Who discovered "wireless?"

But greater wonders were still in store. It was known that electricity sends waves out into space that travel with the speed of light. A man named Heinrich Hertz, in Germany, invented an "eye" that would catch these waves, but it was a young Italian, Guglielmo Marconi, who made the wonderful instruments with which messages could be sent through the air, without wires, over great distances.

The latest result of harnessing the lightning is the wonderful radio that fills our homes with music, and enables the President, sitting in the White House, to talk to the whole nation.

The radio is simply a wireless telephone. The transmitter is the microphone; the receiver

is a little glass bulb, called the audion. Inside of it there is a vacuum and a metal filament which is made to glow by the current from a small electric battery. The audion was invented by a young American, Lee de Forest, who, after finishing a course in electrical research at Yale University, went to work for the Western Electric Company in Chicago, and at night, in his room, carried on experiments with the mysterious electric waves.

Who made the first audion tubes?

Meanwhile, the electricity had been harnessed to do another beneficial job for man. It was made to light his homes and schools, his stores and factories and other buildings, and his public streets.

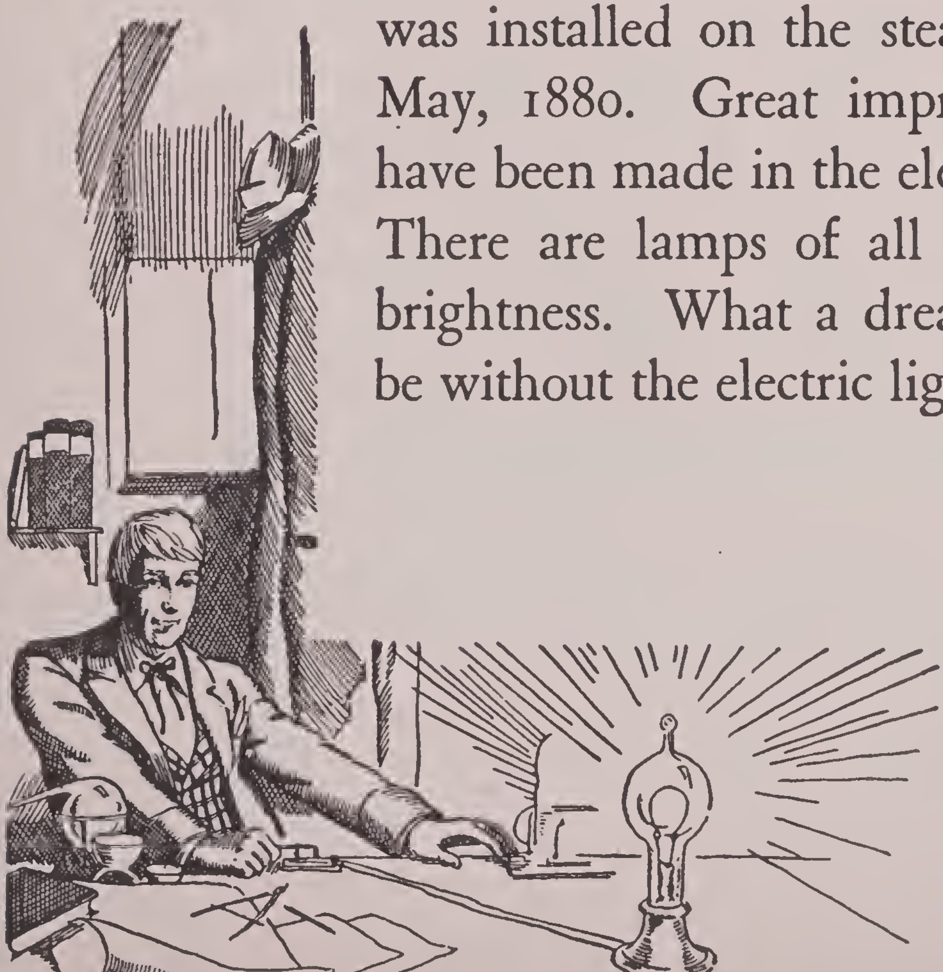
This first electric light was the arc light. Two sticks of carbon were set close together and an electric current forced to leap from one to the other, the resistance of the air making the carbons glow. But the light was too intense and glaring for ordinary use indoors, though fairly satisfactory outdoors.

Who invented the incandescent light?

Thomas A. Edison, one of the world's greatest inventors, succeeded, after many years of hard work, in making an electric light that would serve all common purposes. At last, he gave to the world the incandescent lamp.

It was almost by accident that he hit upon the solution of the problem. He sealed a thread of carbon into a glass bulb from which the air had been pumped out. Then he turned on the electric current. The carbon gave off a beautiful, soft light. The electric current could be made to light many of his lamps; it could be divided into as small units as were desired. This was not the case with the arc lamp.

The first commercial electric lighting plant was installed on the steamship *Columbia,* in May, 1880. Great improvements, of course, have been made in the electric light since then. There are lamps of all sizes and degrees of brightness. What a dreary world this would be without the electric light!



Edison gave to the world the incandescent lamp

Chapter X

THE AUTOMOBILE AND THE AIRPLANE

STEAM ENGINES and electric motors gave mankind power-machines that have changed the world tremendously, and have allowed people more leisure than they have ever had before. At the same time, such inventions have enabled them to produce hundreds of times more goods.

Why do autos need a different sort of engine?

But steam engines and electric motors would not have made possible the wonderful development of the automobile, and they would be absolutely useless for airplanes. The trouble with steam engines is that they are terribly heavy, and in order to make steam a fire has to be kept burning beneath the boiler. Electric motors, also, are heavy and they have to be connected with dynamos in a power station so that they may have a continuous supply of

strong current. To be sure, a certain amount of electricity can be produced by storage batteries, but not very much, and the batteries have to be recharged often.

Both automobiles and airplanes, in order to run for long distances at great speed, require very light engines of high power, and a cheap fuel. There is only one engine that meets these requirements, and that is the gas engine. The gas engine, like the steam engine and the electric motor, had a long history, but it is only within recent years, with the birth of the automobile and of the airplane, that it has become an invention of the utmost importance.

What is the ancestor of the gas engine?

Strange as it may seem, the earliest ancestor of the gas engine is the cannon, which sprang from the invention of gunpowder! For the gas engine gets its power from sudden explosions. Of course, in the gas engine the substance exploded is not gunpowder—it is a mixture of gas and air; and, instead of a cannon-ball, there is a piston in the engine.

As early as the seventeenth century, engines were actually made which got their power from explosions of gunpowder. But these were such dangerous machines that the idea was given up. It was not until the discovery of coal gas, some years after Watt invented his steam engine, that a real gas engine was built, by an Englishman named John Barber. A mixture of gas and air was let into a tank; on being fired, it shot out against the blades of a paddle wheel, making the wheel rotate with great force.

Who built the first gas engine?

Some time later, a French engineer named Lebon invented the scheme of compressing a mixture of air and gas and igniting it by an electric spark. This was a great step forward. In 1860, another Frenchman, Lenoir, built the first really useful gas engine, which was still further improved in 1876 when Otto and Langen, in Germany, invented the four-cycle engine, in which there were four strokes of the piston to each explosion, the gas and air being let into a cylinder. This is the way modern

gas engines work. High-powered automobiles have gas engines with a number of cylinders. A gas engine can get twice as much work as a steam engine out of the same quantity of fuel.

When was the first automobile made?

Meanwhile, efforts were being made to build "horseless carriages" with steam engines. Of course, they were failures. It was not until 1894 that the modern automobile, using gasoline for fuel, was born. The gasoline, evaporating, makes a gas which is exploded by an electric spark plug.

There were many difficult problems to solve before the automobile became the useful servant of man that it is today. Most of the early automobiles were more trouble than they were worth. The engines were always getting out of order, making the cars "go dead" many miles away from a repair shop.

But now all that is changed. Automobiles fitted with engines of tremendous power run smoothly and swiftly over splendid roads. In the United States alone there are some twenty-

five million automobiles in use, and the country has been covered with a network of wide roads for them to travel on. Great motor trucks carry all kinds of merchandise, and motor buses furnish cheap transportation between towns and take the country children to and from fine central schoolhouses.

While all this was going on, men were trying to solve the age-old problem of flight through the air. Ever since man has lived on the earth he has envied the birds, because they could do easily and naturally something that he could not; they could fly. For hundreds of years, man's attempts to fly all ended in dismal and often tragic failure.

When did man first fly in the air?

It was thought that the key to the problem had been found when the balloon was invented. It was in 1783 that the first successful flight through the air by balloon was made.

The first balloons were filled with hot air, which, being lighter than cool air, rises above it. Later balloons were filled with hydrogen,

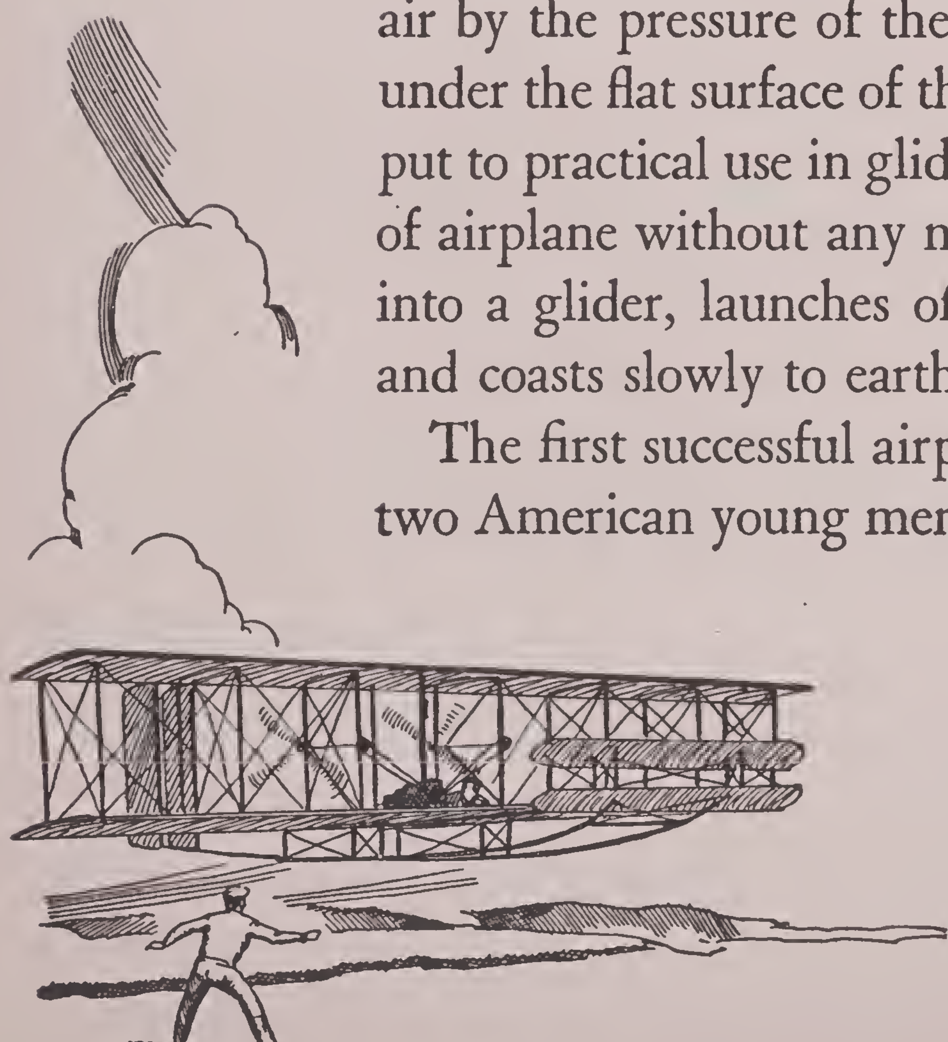
a very light gas. These balloons were big, round bags of oiled silk. But balloons could not be guided.

What is a dirigible?

From balloons there gradually developed dirigible airships; that is, airships that can be steered. The gas bags of these airships were shaped like cigars. Santos-Dumont, of Brazil, flew such an airship around the Eiffel Tower, in Paris, in the year 1901. Count Zeppelin, of Germany, made improvements in the dirigible and built a new model of the kind now known as Zeppelins.

The ancestor of the airplane was not the balloon but the kite. The kite is supported in the air by the pressure of the wind as it rushes up under the flat surface of the kite. The idea was put to practical use in gliders. A glider is a sort of airplane without any motor. The pilot gets into a glider, launches off from a high place, and coasts slowly to earth.

The first successful airplane was invented by two American young men; they were brothers,



The first successful airplane was invented by two Americans

named Orville and Wilbur Wright. When they were little boys they became interested in flying. They read everything that they could find on the subject, particularly about the gliders that were being experimented with in Germany. Finally they built a glider themselves, and during several summers they made tests with it among the North Carolina sand dunes.

Who invented mechanical flight?

Their problem was how to control the glider, how to steer it, and how to keep it from being turned over by the wind. After years of patient work they learned how to construct a machine that they could control perfectly, and that needed only a suitable motor.

Finally, they found the right motor, and the first real airplane was born. The machine had two planes, and it was kept in balance by skillful twisting of the planes, by means of ropes, to adjust them to the changing air-currents. The little craft weighed only slightly more than 200 pounds, and it was run by a four-cylinder gasoline motor of sixteen horsepower.

When was the first mechanical flight made?

On December 17, 1903, at a lonely place near Kitty Hawk, along the sandy shores of North Carolina, the brothers first tested their airplane. Four successful flights were made. It was the first time in history that real flight had been achieved by mechanical power.

Man at last had conquered the air; he had grown wings and could use them as birds could. We have not space to tell about the development of the airplane since then; how it was improved, made larger, fitted with more powerful motors and propellers, and its speed increased until it could leave behind the fastest trains.

A few years ago a brave young man named Charles Lindbergh flew from New York to Paris, without stopping, in a little more than thirty-three hours, at an average speed of 108 miles an hour. Another daring American, Admiral Byrd, has flown over both the North Pole and the South Pole.

And the airplane is as yet only in the childhood of its usefulness to man.